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成 果 報 告 書

石炭水素添加ガス化技術開発
社会適合性に関する調査研究

国際協力可能性調査

北京煤化学研究所　報告書

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（社）日本エネルギー学会

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委託先　　(社) 日本エネルギー学会

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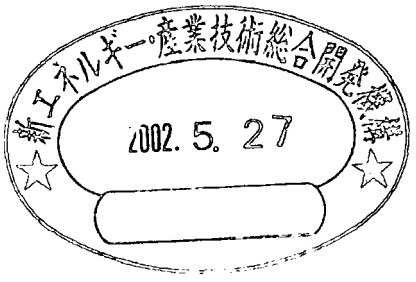
将来、天然ガス供給の逼迫の可能性に鑑み、世界的に偏在することなく豊富に存在する石炭を原料として、高品質の代替天然ガスを低廉且つ大量に製造する可能性を有する石炭水素添加ガス化技術の確立を最終目的として、この実用化を評価する上で必要な社会適合性に関する調査研究を５ヵ年計画として行なった。

平成 12 年度においては、中国のウルムチ市および大同市についてエネルギー需給見通しとその問題点、天然ガス資源とその利用計画、都市ガス事業の実態と将来計画等を調査した。その一環として中国煤炭科学研究総院・北京煤化学研究所に調査を委託した。

本報告書は、その成果を取りまとめたものである。

The Feasibility of Coal Hydrogasification Technology in China II

Final Report



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The Feasibility of Coal Hydrogasification Technology in China II

1 Preface

1.1 Review to the work in 1999

In 1999, commissioned by Japan Institute of Energy (JIE), Beijing Research Institute of Coal Chemistry (BRICC) of China Coal Research Institute (CCRI) conducted a comprehensive and thoroughgoing investigation into the "Feasibility of Hydrogasification Technology in China", under the guidance of National Planning Committee, and submitted the final report of the research on the "Feasibility of Hydrogasification Technology in China" to JIE.

The main work of last year was the comprehensive investigation into the status and development of nature gas resources in China, the status of town gas for major Chinese cities, the status and prospect of coal exploitation and utilization in China, and the valuation of mining area and coal-quality suitable for hydrogasification in China. According to the specific situation of the nature gas, town gas and coal resources in China, Shanghai (上海), Shanxi (山西) Province, Shenhua (神华) of Shaanxi (陕西) Province and Xinjiang (新疆) Uigur Autonomous Region (Simplified as "Xinjiang") were recommended as the candidate sites for hydrogasification to JIE. A preliminary investigation was made into the situation of economic development, the status and future of energy demand and supply, and the status and future development of town gas in the four areas above-mentioned, and some essential information was provided at the same time. It was considered that the hydrogasification technology was feasible in China for its accordance with the development of energy technology.

1.2 Work in 2000

Through the work in 1999, JIE has a considerably comprehensive understanding of the status and future development of the town gas and the feasibility of hydrogasification technology in China, which lays a fine foundation for the future cooperation of both sides.

In order to commercialize hydrogasification technology, BRICC and JIE have signed an agreement of "the Feasibility of Coal Hydrogasification Technology in China II" for the further cooperation. According to the agreement the main work of 2000 is as follows:

① The representative Urumchi (乌鲁木齐) of Xinjiang and the circumjacent region of Taiyuan (太原) of Shanxi Province were selected as the major sites for hydrogasification technology, moreover, the circumjacent region of Taiyuan was confirmed as Datong(大同) of Shanxi Province due to the actual situation of the Chinese coal resources and future development and nature gas (the reasons of this selection is detailed in Appendix 1). A further comprehensive investigation was made into the specific situation of these two cities, which involves: the specific situation of the selected cities and the other cities around them; the status and the future

development of the public facilities; the status of the existed coal gas factories、the coal gas pipeline construction and the coal gas consumption; the present nature gas pipeline and future construction programme; the conveying of the gasification products of the hydrogasification factory; the possibility of utilization of the by-products; the situation of industries concerned with coal chemical engineering, and so on.

② The on-the-spot investigation was made on the status of town mines, city gas and gas pipeline network construction of Urumchi of Xinjiang and Datong of Shanxi Province by two Japanese delegations respectively on the 1st -4th of June, 2000, and the 23rd-30th of September, 2000. The colloquia were held on the cooperation in the field of coal hydrogasification technology between the delegations and the administrative personnel from Datong Planning Committee, Xinjiang Planning Committee, some other departments and enterprises. The specific investigation report is shown in Appendix 2.

③ According to the agreement, the coals from Liudaowan (六道湾) Mine under Urumchi Mining Bureau and Sitai (四台) Mine in Datong (大同) were sampled for the experiments of hydrogasification, and analyzed respectively by both sides. The views were exchanged on the results of analysis. The analysis report is detailed in Appendix 3.

④The preliminary experiments of hydrogasification of coal samples from Xinjiang (新疆) and Datong (大同) were made by BRICC, the test report is detailed in Appendix 4.

⑤The preliminary investigation and data analysis were made by BRICC on the strategy of the future sustainable development of energy in China, and the research report of "Sustainable Development Strategy of Energy in China" is proposed in Appendix 5.

⑥According to the agreement, an intermediate seminar was held in BRICC, together with Japanese delegation, on the 22nd of September in 2000. The investigation on the feasibility of coal hydrogasification technology in China was reported by BRICC, and the lately development of hydrogasification technology was introduced by Japanese delegation. Both sides have exchanged the views on some issues and future collaborative work.

After almost a half year of work, BRICC has completed the investigation on the basic status of two selected sits—Urumchi of Xinjiang Autonomous Region and Datong of Shanxi Province, and proposed some suggestion on the feasibility of hydrogasification technology in China. Moreover, some research work on coal gasification conducted by BRICC and Institute of Coal Chemistry (ICC) of Chinese Academy of Sciences was introduced. The final report of this project is now presented to Japan according to the agreement.

2 Urumchi, Xinjiang Uigur Autonomous Region

2.1 General situation of Urumchi and the candidate site for the factory

2.1.1 General situation of Urumchi

• General situation of Urumchi City

Urumchi (乌鲁木齐) is located on the north of middle- Tianshan (天山) Mountain and the

south of Zhunger (准噶尔) Basin, from east longitude 86°37′33″ to 88°58′24″, and north latitude 42°45′32″to 44°08′00″. Urumchi is the capital city of Xinjiang (新疆) Uigur Autonomous Region. It is also the political, economic and cultural center of Xinjiang, and the bridgehead of the second Eurasia bridge in the west of China. There are 7 districts and 1 county under the Urumchi city, that is: Tianshan (天山) district, Shayibake (沙依巴克) district, Xinshi (新市) district, Shuimogou (水磨沟) district, Toutunhe (头屯河) district, Dongshan (东山) district, Nanshan (南山) mining area and Urumchi county. The whole area of the city is 12000 km^2, in which the planning area is 1600 km^2, and the built area is 139.55 km^2. By the end of 1999, the whole population in the city is 1,589,200, which involves 17.5 percent of agriculture population and 27.1 percent of minority nationality population.

In Urumchi, there are Tianshan glacial and firn field of 164 km^2, over 60,000 ha cultivated area, over 600,000 ha grassland, 90,000 ha natural forest, 5,333ha water field, and 10 billion tons coal reserves. There are also plenty of minerals reserves (such as salt, mirabilite, kerogen shale and copper) and energy of light, heat and wind which will be exploited soon.

• Transportation of Urumchi

Urumchi is an important pathway to the outside in the west of China, and the main hub of communications in Xingjiang. Urumchi airport is one of 5 biggest airports in China, and it has had 58 international, national and provincial airlines. Urumchi Railway Station is one of the important marshalling stations in the country with a pair of international train and 13 pairs of national and provincial trains. The highways of the city radiate in all directions. National Road No.312, No.216 and No.314 cross the city district and link up the whole province and peripheral countries. Hetan (河滩) expressway in the city district is connected with Tu-Wu-Da (土-乌-大) and Wu-Kui (乌-奎) expressway. In Urumchi, there has basically established the road netting system: there is 966 kilometer-long roads whose total area is 10,730,000 m^2, and 90 bridges of many kinds that includes 15 overpasses.

• Economic situation of Urumchi

In the recent years, supported by the policy of "large scale development of western region" of the government, Urumchi has strengthened the reformation so that the economy kept up a steady growth and social facilities made new achievements. In 1999, the employees are 836,100, of which 538,200 are in the state-owned enterprises, 267,400 are in the collective enterprises and 22,400 are in the other economic units. The GDP of the whole city is 24.9 billions yuan (RMB), which has increased 7.8% more than the last year. The increase value of the primary industry is 0.39 billion yuan, which is 2.7% less than the last year; that of the secondary industry is 9 billion yuan, which is 4.8% more than last year; and that of the tertiary industry is 15.54 billion yuan, which is 10.4% more than last year. The average wage of staff and workers is 9366 yuan a year. The average income of the urban population is 6676 yuan, and the average consumption expenditure of the urban population is 5184 yuan. The pure income per capita of the farmers and herdsmen is 3226 yuan. The main characteristics of the economic development are: the even

increase of the industrial production, the steady improvement of market sales, the low prices and the balances of financial and monetary situation. While the present problems are: the slow adjustment of the economic structure, the relatively low speed and quality of the economic growth and the low economic benefit of the enterprises.

The main economic index and the output of main products are respectively shown in table 2-1, 2-2 and 2-3.

Table 2-1 Main Economic Index and GDP of Urumchi (1999) (Unit: 10^4 yuan)

GDP	Primary Industry	Secondary Industry	Tertiary Industry
2487769	387720	89508	1553968

Source of the data: *Statistical Yearbook of Urumchi (2000).*

Table 2-2 Output of Main Industrial Products of Urumchi (1999)

Total Output Value of Industry	Raw Coal	Electricity	Crude Oil Processing	Synthetic Ammonia	Cement	Steel Products
(10^4 yuan)	(10^4 ton)	(10^8 kWh)	(10^4 ton)	(10^4 ton)	(10^4 ton)	(10^4 ton)
2176544	660.65	42.84	334.39	80.31	224.56	115.55

Source of the data: *Statistical Yearbook of Urumchi (2000).*

Table 2-3 Total Output Value of Farming, Forestry, Animal Husbandry and Fishery and Output of Main Agricultural Products of Urumchi (1999)

Main Economic Index (10^8 yuan)	Totle Output Value	Farming	Forestry	Animal Husbandry	Fishery
	7.85	5.38	0.07	2.18	0.22
Output of Main Agricultural Products (ton)	Grain	Rapeseed	Vegetables	Sugar Beet	Meat
	91717	11391	445598	10056	12035

Source of the data: *Statistical Yearbook of Urumchi (2000).*

In 1999, the volume of international trade of the whole city is 1.026 billion US$, which increases 2.41% more than the last year. Among this, the volume of importation is 0.362 billion US$, and that of export is 0.664 billion US dollar, which increases 21.04% more than the last year. Urumchi is famous for its tourism. In 1999, about 107,500 foreign visitors came to Urumchi, and the tour income is 0.255 billion yuan (RMB).

- **Present situation of energy industries and future demand for energy in Urumchi**

Xinjiang is one of the key exploitation regions in the 21st century in China. It is also one of the major provinces (districts) of energy supply in the future and an important strategic substitute region of energy supply. It is estimated that the annual increase rate of economy can get to 8-10% in the future decade. There are much plenty of energy resources in Urumchi. The proven reserves of coal, oil and nature gas are in the priority of the whole country, and the deposit occupancy per capita is also in the priority. The present situation of energy industry in Urumchi is shown in table 2-4.

Table 2-4 Output and Consumption of Primary Energy in Urumchi

Output				
Year	Raw Coal (10^4 ton)	Crude Oil (10^4 ton)	Nature Gas (10^4 m^3)	Electricity (10^8 kWh)
1990	501.49	171.01		24.85
1995	617.92	229.79		27.43
1997	669.64	286.07	24766	34.41
1998	720.67	341.29		39.0810
1999	660.65	334.39	42989	42.8443

Consumption				
Year	Raw Coal (ton)	Crude Oil (ton)	Electricity (10^4 kWh)	Nature Gas (10^4 m^3)
1997	5003050	2881815	341589	24766
1999	5156387	3326440	381212	42989

Ratio of Energy Consumption (1999)				
	Raw Coal (10^4ton)	Crude Oil (10^4ton)	Electricity (10^4 kWh)	Nature Gas (10^4 m^3)
Consumption of Industrial Production	508.92	332.64	353429	42989
Consumption of nor-industrial Production	6.72		3416	

Consumption of Major Resources of Energy (1997)								
	Raw Coal (ton)	Ratio (%)	Crude Oil (ton)	Ratio (%)	Electricity (10^4 kWh)	Ratio (%)	Nature Gas (10^4 m^3)	Ratio (%)
Excavating Industry	297828	1.95	-		9145	2.68	-	
Manufacturing Industry	2496070	49.89	2881529	96.31	254241	74.43	24766	100
Industry of Producing and Supplying Electricity, Gas and Water	1845075	36.88	-		41568	12.17	-	
Architectural Industry	80811	1.61	-		7166	2.10	-	
Transport, Postal and Telecommunications Service	283266	5.66	286		9618	2.82	-	

Source of the data: *Statistical Yearbook of Urumchi (2000).*

From the table 2-4, it can be known that the energy supply of Urumchi is mainly from coal, oil, nature gas and electricity, and among these, coal makes up a relatively great ratio, which guarantees a plentiful energy supply. In the structure of energy consumption, industry, which is a main part of energy consumption, makes up more than 90 percent of the total consumption. According to the ratio of energy consumption of industries in 1997, the ratio of raw coal and electricity consumption in excavating industry is respectively 1.95% and 2.68%; the ratio of raw coal, crude oil, electricity and nature gas consumption in manufacturing industry is respectively 49.89%, 96.31%, 74.43% and 100%; the ratio of raw coal and electricity consumption for producing and supplying electricity, gas and water is respectively 36.88% and 12.17%; the ratio of raw coal and electricity consumption in architectural industry is respectively 1.61% and 2.10%;

the ratio of raw coal and electricity consumption in transport, postal and telecommunications service is respectively 5.66% and 2.82%.

The economic region of the north-Tianshan (天山) Mountain centers on the Urumchi City, which is the area with the developed region and the center of energy production and consumption in Xinjiang. The coal production of this economic region makes up more than half of the whole province, and there is the biggest electricity network of the whole province in the region, which ensures plentiful energy supply. According to the speed of economic development of Xinjiang, the demands for energy and the objective of "building Xinjiang into the oil base and energy base of the country in the 21st century", it is estimated that Urumchi, as a center city of energy consumption, will reduce the percentage of coal in the structure of energy production and consumption and increase the percentage of oil and nature gas year by year.

• Environmental situation of Urumchi

Urumchi, as a center city of energy consumption, is suffering the serious air pollution which is resulted by its mountains surrounding geographical conditions. The annual average index of air quality is about 3 (it is generally 2 in summer and autumn and ≥ 3 in winter and spring). And the grades of air quality are shown in table 2-5. The annual rainfall is 160～230 mm, which concentrated from May to September. The pH value of the rainfall is from 6.35 to 8.18, and there is in no acid rain. 99.7 percent of drinking water resources meet the standard, and there is a slight pollution in some groundwater, lakes and reservoirs. The annual average equivalent grade of environmental noise is 57.7 db. A 66.67-km^2 green belt has been established on the barren hills round the city. The area of the gardens and green lands is 6296 ha, and 19.86 percent of built areas are green lands.

Table 2-5 Grades of Air Quality in Urumchi Unit: week

Year	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1998	0	11	20	8	13
1999	0	7	31	5	9

Source of the data: *Statistical Yearbook of Urumchi (2000)*.

At present, the strategy of "large scale development of western region" has been put into effect, and the improvement of the ecological environment and basic facilities is supported in particular. Urumchi government has set about a "blue sky project" which will improve the environmental quality of the city, and some achievement has been made in environmental protection in 1999. In the whole year of 1999, 268 coal-buring boilers were removed, 533 small-scale boilers were removed, and the dust emission has been controlled in 8 cement plants round the city. In 1999, the green lands increase by more than 266.7 ha, and the days with over 3 air quality index has increased from 57.7% of the last year to 71.29%. As the whole, the quality of the environment has been improved greatly.

2.1.2 Coal resources of Urumchi

• Coal resources

Xinjiang Uigur Autonomous Region is located on the border area with a vast territory. There are plentiful coal resources in Xinjiang. Most coal seams were formed in Mesozoic Middle- and Lower- Jurassic coal seams, some are Late Triassic coal seams, and a few are Neopaleozoic coal seams. The coal- bearing strata are mainly distributed in Zhunger (准噶尔) Basin, the edge of Talimu (塔里木) Basin and some middle-size and small-size basins between Tianshan (天山) Mountain and Kunlun (昆仑) Mountain, and the total number of the coalfields or the coal mines is 57. In the proven coal resources, the reserve of lower metamorphic bituminous coal of Xinjiang makes up 24.5 percent of that of the whole country, which ranks the third after Shaanxi (陕西) Province and Inner Mongolia Autonomous Region; and the reserve of gas coal to meager lean coal of Xinjiang occupies a certain share, which ranks the 7th among the whole country. The proven coal reserve in Xinjiang is about 11 bt, and the occupancy volume of coal per capita is about 780 ton. The coal resources of Xinjiang are rich in both reserves and types. The coal types are mainly steam coals; in addition, there are also certain quantities of coals for coking.

The Urumchi mining area is 30 km away from the northeast of the Urumchi City. It is from the Urumchi River in the west to the Tiechanggou (铁厂沟) River in the east, and the transmeridional length is 27 km, the width is 6-8 km from south to north. The attitude is 672-1040 m. Generally, the traffic of this area is convenient. There are 5 coal mines, 2 steam coal preparation plants and 3 screening systems for coal refuse under the Urumchi Mining Bureau. The 5 pairs of mines are located from west to east as: Liudaowan (六道湾) Mine, Weihuliang (苇湖梁) Mine, Jiangou (碱沟) Mine, Xiaohouggou (小红沟) Mine and Dahonggou (大洪沟) Mine. The total designed capacity of the mines is 2.45 Mt a year. In addition, there are 1 coal refuse cement plant with annual output of 50 kt, and 1 architectural pottery plant with annual output of 400 km^2 in the mining area. Moreover, there is coal washery for steam coal separately in Liudaowan (六道湾) Mine and Jiangou (碱沟) Mine, and simple screening plant in another 3 mines.

Table 2-6 Production and Construction of Mines

Item / Mine	Number of Mined Coal Seams	Coal Class	Recoverable Reserves (1995) (10^4 ton)	Designing Productivity (10^4 ton)	Actural Productivity (10^4 ton)	Time of Putting into Production	Output (1995) (10^4 ton)
Liudaowan (六道湾煤矿)	33	Long flame coal, Weakly caking coal	9659.7	90	90	1968	74.88
Weihuliang (苇湖梁煤矿)	33	Long flame coal, Weakly caking coal	11894.5	120	75	1980	60.69
Jiangou (碱沟煤矿)	32	Long flame coal, Weakly caking coal	13041.2	40	30	1980	41.65
Xiaohonggou (小红沟煤矿)	32	Long flame coal, Weakly caking coal	9364.9	30	10	1983	26.69
Dahlonggou (大洪沟煤矿)	27	Long flame coal, Weakly caking coal	306.8	10	9	1983	21.62
Total		Long flame coal, Weakly caking coal	44267.1	290	229	1994	229.46

Source of the data: *Assembly of Materials of Coal Quality of Urumchi Mining Bureau (1995).*

In this area, the coal-bearing strata are Jurassic and Quaternary, which can be divided into 3 series: upper, middle and lower series. The thickness of lower-stratum is 750-900 m, which contains 4 recoverable and partial recoverable seams, and the total thickness of the recoverable seams is 14.14 m. The thickness of middle-stratum is 737-903 m, which contains 27-34 recoverable seams.

The recoverable reserves of the Urumchi Mining Area are 688 Mt, and the coal classes are long flame coal and non-caking coal. The designing capacity of 5 mines are: Liudaowan Mine (900 kt), weihuliang Mine (750 kt), Jiangou Mine (400 kt), Xiaohonggou Mine (300 kt) and Dakonggou Mine (100 kt), and the total capacity of the whole Bureau is 2.9 Mt. The actual production in 1997 is 2.615 Mt.

• **Present coal processing**

There are coal washeries for steam coal separately built in Liudaowan Mine and Jiangou Mine, and there are also simple screening plants built in Weihuliang Mine, Xiaohonggou Mine and Dahonggou Mine.

The original design of Lindaowan Coal Washery is to remove coal refuse by hand (+100mm) and jig washer (100-25mm), and now it has been changed to remove coal refuse by hand (+125mm) and jig washer (125-50mm). In Jiangou Coal Washery, there are 3 grades of ROM coal: +100mm, 100-13mm and 13-0mm. It was designed originally that the coal of +100 mm was broken at first, and then washed with jig washer together with the coal of 100-13mm. But the crushing mill was not assembled when the coal washery was erected. So at present it has been changed to remove coal refuse by hand (+100mm) and jig washer (100-50mm).

Table 2-7 Situation of Processing, Storing and Loading of Coal

Item / Mine	Time of Putting into Production	Capacity of Preparation (10^4 ton/year)	Handling Capacity of ROM Coal (1995) (10^4 ton)	Capacity of Warehouse (t)		Capacity of Coal Yard (ton)	Ways of Loading	Present Processing
				Lump Coal	Mix Coal			
Liudaowan Coal Washery (六道湾洗煤厂)	1968.8	90	78.72	160	1040	mix 12000	mechanical loading	grade by 50mm, refuse of lump coal is removed by jig washer
Weihuliang Screening Plant (苇湖梁筛选厂)	1980.12	75	50.55	30	500	mix 20000	coal mixing machine, hand loading	grade by 70mm, refuse of lump coal is removed by jig washer
Jiangou Coal Washery (碱沟洗煤厂)	1986.10	30	24.61	200	400	mix 10000	mechanical loading	grade by 50mm, refuse of lump coal is removed by jig washer
Xiao honggou Screening Plant (小红沟筛选厂)	1988.10	30	14.60	50	50		hand and mechanical loading	grade by 70mm, refuse of lump coal is removed by jig washer
Dahonggou Screening Plant (大洪沟筛选厂)	1994.4	10	16.59	10	80		hand and mechanical loading	grade by 50mm, refuse of lump coal is removed by jig washer

Source of the data: *Assembly of Materials of Coal Quality of Urumchi Mining Bureau (1995).*

The screening plant of Weihuliang Mine was designed originally to grade by 50 mm. But the belt is so short that the coal refuse can't be removed completely. So it changes to grade by 70 mm now. In the screening plant of Xiaohonggou Mine, it was designed that the ROM coal was screened into 3 grades: 125-50 mm, 50-25 mm and 25-0 mm. Now, the coal refuse is removed separately by loading (+125 mm) and by hand (125-75 mm), and the coal of –75 mm is sold in other area as mixed coal. The screening plant of Dahonggou Mine was designed originally to grade by 50 mm, which caused that the coal refuse couldn't be removed completely, so it changes to grade by 100 mm now. The coal refuse of +100 mm is removed by hand, and the coal of –100 mm is sold in other areas as mixed coal.

Now the designing productivity of Weihuliang Mine has extended from 750 kt to 1.2 Mt a year. The ability of the screening and breaking system is 1.2 Mt a year, and the wash ability is 600 kt a year.

• **Situation of coal geology and coal measure strata**

①Strata

The mining area of the east Urumchi River is located between the east Urumchi River and Baiyang (白杨) River, which is on the southeast edge of Zhunger (准噶尔) Basin and the north west of Bogeda (博格达) Mountain. The east-west length is 27 km, while the south-north width is 6-8km. The height above the see level is 672-1040m. The strata are mainly Jurassic and Quaternary. Jurassic strata are composed of Lower, Middle and Upper Series. Lower Series consist of Badaowan (八道湾) Group and Sangonghe(三工河) Group, Middle Series consist of Xishanyao (西山窑) Group and Toutunhe (头屯河) Group, and Upper Series consist of Qigu (齐古) Group. The total thickness of Jurrassic strata is about 3400m. Badaowan (八道湾) Group of Lower Series is limnogenic coal deposit, which is mainly pulveryte. The thickness of the coal-bearing strata in the mining area of the east Urumchi River which is under unified central planning is 750-900m, which contains 4 recoverable and partial recoverable seams, and the total thickness of the recoverable seams is 14.14m. Xishanyao (西山窑) Group of Middle Series is limnogenic coal deposit, which is mainly siltite and pulveryte mingled with lenticle siderite. The thickness of the coal-bearing strata in the mining area of the east Urumchi River is 737-903m, and the average thickness is 765m. The strata contain 27-34 coal seams. The favorable thickness is 96.32-190.97m, while the average thickness is 138.29m. The coefficient of coal bearing is 15.3-28.1%.

②Structure

Baodaowan (八道湾) syncline: The distribution of the strata is wider in the east-west trend. The junction is plunging towards the south, and the plunge is 40°-70°. The length of the axis is 18km, ended by the fault zone F2 in the west side. The strata of the west wing are cliffy in the south and glacis in the north. The plunge of the south side is 70°-85°, with partial stand-up and overturning, while that of the north side is 45°-60°. Qidaowan (七道湾) anticline: It is syncline plunging, the south side of the anticline is just the north of Badaowan (八道湾) syncline. The

north of the anticline is erected or overturned because of the fault effect of F2.

Besides the biggest fault F2, there are smaller faults (F1 and F3) in this area. F1 (Jianquanzigou, 碱泉子沟, Fault) is mainly distributed in the north of monoclinic sector between Jianquanzigou (碱泉子沟) and Lucaogou (芦草沟). F3 (Baiyangbeigou, 白杨北沟, Fault) is mainly distributed in the south of synclinic sector between Baiyangou (白杨沟) and Lucaogou (芦草沟). J1B coal measures of Badaogou (八道沟) Group in the south of mining area are cut by F1 and F2, and a group of coal samples in the bottom are destroyed, so that the coal measure in the south wing of Baiyangnangou (白杨南沟) anticline-lifted and then was eroded. In the center of the mining area, a reversed fault (F2) of regional trend is developed on the axis of Qidaowan (七道湾) anticline, which cut the south-north vat (No. 34+35 seam and No. 30+33 seam) of J2X coal measures in Xishanyao (西山窑) Group, and the perpendicular throw is 500-8000m, the horizontal shift is 4500.

• **Characteristics of coal and its changes**

①coal-bearing characteristic

Xishanyao Group (J2X) that is now mined contains 27-34 coal seams, and the rock crosscut of 700m can penetrate more than 30 coal seams, which belongs to typical short-range coal seams group.

The correlation of the coal seams is distinct. The coal groups can be divided from lower to upper as: No. 30-35 (B1-B2) in the middle and lower seams is the first group of coal (south vat); B3-B6 is the second group (north vat). Among these, except for No.33, the other coal seams are all stable. No.36 coal seam in the bottom is less stable. No. 16-29 in the upper and middle seams is the third group (small groove). In this group, No.27, 28 are not stable, No.19, 21, 24, 26 and 29 are less stable, and the others are stable. No.1-15 in the upper seams is the fourth group (small groove). The first and the second group belong to the extra-heavy coal seams, with quite simple structure and good quality. The third group is mainly medium-heavy coal seams. The forth group becomes thin coal seams gradually along the east trend, with more horse and worse quality. Especially in some places round Dahonggou (大洪沟), there are chaotic mudstones immingled in coal seams.

The total favorable thickness of recoverable coal seams in the mining area is 138.29m. 5 mines under Urumchi Mining Bureau are all located on the south wing of syncline, which are ranged from west to east as: Liudaowan (98.25m), Weihuliang (127.99m), Jiangou(190.37m), Xiaohonggou (188.21m) and Dahonggou(96.32m). There is only 1 mine—Tiechanggou (铁厂沟) open-cut mine under unified central planning, which is in construction now, on the north wing of syncline, and its position can be correspond with Dahouggou and Xiaohonggou on the south wing.

The spacing interval among the Group 1, 2 and 3 is almost more than 100m, while that between the Group 3 and 4 is decreasing gradually from west to east: it is 60 m at the western Liudaowan, and then merges into Group 4 at Dahonggou. And the spacing interval between the

Group 1 and 2, which are more stable, decreases sharply to less than 10m along the east from Dahonggou Mine.

②Main characteristics of coal

The physical properties of coal seams are similar to each other: near asphalt color, black or brown streak, glassy and semi-glassy luster and stripped or homogeneous structure. The lithotype of coal is mainly olrain (about 80%), then durain and fusain (about 10-20%) and a few of vitrain. The type of coal is mainly bright and semi-bright coal, and then is dull coal. The class of coal is weekly caking coal (in the lower seams of the coal-bearing strata) and long flame coal (in the middle and upper seams).

③Quality analysis of coal in seams

Raw coal in Group 1 and 2 : A_d 8—20%, M_{ad} 2—4%, $Q_{gr,daf}$ 31—33MJ/kg, $S_{t,d}$ 0.5—1.5%; float coal : A_d 4—8%, M_{ad} 2—5%, $Q_{gr,daf}$ 32—34MJ/kg, $S_{t,d}$ <1%, CRC 1-4, V_{daf} 30—37%, C_{daf} 82-84%, O_{daf} 8-10%。

Raw coal in Group3 and 4 : A_d 7—30%, M_{ad} 2—4%, $Q_{gr,daf}$ 30—32MJ/kg, $S_{t,d}$ 1.0—1.5%, float coal : A_d 4—8%, M_{ad} 2.5—4%, $Q_{gr,daf}$ 31—34MJ/kg, $S_{t,d}$ 0.8-1.5%, CRC 2-4, V_{daf} 38—42%, C_{daf} 79-81%, O_{daf} 10-12%。

Comparing the lower seams with the upper seams: the content of carbon in the lower seams is about 1-2% more than that in the upper seems; the content of oxygen is about 1-2% less than that in the upper seems; and $Q_{gr,daf}$ is 1-3 MJ/kg more than that in the upper seems. The degree of metamorphism of the Group 3 and 4 in the upper seams is lower than that of the Group 1 and 2. V_{daf} of the float coal of the Group 3 in the middle seams is often less than 37%, and $G_{R.I}$ is less than 5, sometimes more than 5 (changing between non-caking coal and weekly caking coal). Owing to the more refuse in the seams of Group 3 and 4, A_d of both groups increases, and $S_{t,d}$ is also distinctly more than that of the Group 1 and 2. The form of sulfur is mainly pyrites, and the content of sulfur will decrease after washing.

Table 2-8 Coal Quality of Main Mines in Urumchi Mining Area

	M_{ad} %	A_d %	V_{daf} %	$S_{t,d}$ %	CRC	$Q_{gr,ad}$ MJ/kg
Weihuliang (苇湖梁矿)	3.45	15.73	39.41	1.08	1-3	27.07
Jiangou (碱沟矿)	4.44	16.68	41.45	1.05	1	26.08
Xiaohonggou (小红沟矿)	3.33	19.43	44.69	1.60	1-3	24.34
Dahonggou (大洪沟矿)	3.98	24.27	41.64	1.33	1	22.86
Liudaowan (六道湾矿)	2.45	14.87	37.91	1.03	1-3	27.11

Source of the data: *Assembly of Materials of Coal Quality of Urumchi Mining Bureau (1995).*

The comprehensive columnar chart of coal-bearing strata is show in figure.

• **Prices of coal**

The prices of coal production are determined by the Autonomous Region. At present, the price of raw mixed coal is 100-120 yuan per ton. The retail prices of household coal are respectively: lump coal: 117 yuan per ton (Liudaowan coal yard); mixed coal: 91 yuan per ton (Liudaowan coal mine).

2.1.3 Sites selection for hydrogasification

• Sites selection

According to the specific conditions of coal production and basic facilities in Urumchi, we suggest selecting Urumchi Mining Bureau as the site for hydrogasification. The concrete position is the No. 50, Wuqu (乌奇) Road, Dongshan (东山) District, Urumchi.

The location of candidate site for hydrogasification factory is show in figure.

• **Transportation and location of Urumchi Mining Bureau**

Urumchi Mining Bureau is 25 km away from the center of the city, and connected with the center of the city through Tulufan-Urumchi-Dahuangshan highway (吐鲁番-乌鲁木齐-大黄山). There are 5 mines under the Bureau, and all of them are 5-15 km away from the Bureau. The nearest Liudaowan(六道湾) mine is only 7 km away from the center of the city. There is convenient traffic in all of the mines, which are connected with each other by standard asphalt roads, and all of these roads can get to the urban. In the respect of railway, there are Lanxin (兰新) Railway across the center of the mining area and two special railways. And in main mines, there is storing and loading system which can be connected with the national railway directly.

2.2 Present situation of public facilities in Urumchi and in the vicinity of the selected site

2.2.1 Power facilities

• **Power supply**

In these years, according to the policy of "developing heat-electricity stably, exploiting hydroelectricity actively, accelerating the development of gas-electricity, developing wind - electricity moderately, and constructing the electric network energetically", Xinjiang Autonomous Region has applied itself to developing the heat-electricity construction with high quality、high efficiency and high-capacity machine units, and the hydroelectricity with good conditions、large capacity flux and concentrated fall, which can adjust the water supply based on main reservoirs. The construction of the electric network complies with the principle of "uniform programming, powerful construction and reformation of the electric network and coordinated development of far and near electric network". In past years, the power industries of Xinjiang Autonomous Region have achieved rapid development. In 1999, the electricity generation of the whole Region is 16.93 billion kWh, and the total installation capacity is 3975,300 kW (among this, hydroelectricity: 19.93%, heat-electricity: 78.36%, wind-electricity: 1.71%). In 1999, the installed capacity of Urumchi electric network is 2050,000kW, and the actual electricity generation is 4.284 billion kWh, which makes up 25.30 percent of that of the whole Region. In Daban (达坂) Town of

Urumchi, the installation capacity of the wind-electricity is 67,700 kW, and the annual electricity generation is 0.2 billion kWh. As a whole, Urumchi has the plentiful ability of power supply.

Table 2-9 Total Electricity Generation in Urumchi (1990-1999)

Unit: 10^8 kWh

Year	1990	1995	1997	1998	1999
Production of Electric Energy	24.85	27.43	34.41	39.08	42.84

Source of the data: *Statistical Yearbook of Urumchi (2000).*

• Power consumption

The power consumption in Urumchi is mainly industrial consumption. In 1999, the power consumption of the industries is 2.62 billion kWh, that of farming, forestry, animal husbandry, fishery and water conservancy is 0.189 billion kWh, and the living consumption is 0.497 billion kWh. And the specific power consumption is shown in table 2-10.

Table 2-10 Power Consumption of Urumchi

Unit: 10^4 kWh

Year	1990	1995	1996	1997	1998	1999
Total	173475	275886	325251	341589	358814	381212
Farming, Forestry, Animal Husbandry, Fishery and Water Conservancy	8670	13861	16788	21535	18027	18929
Industry	126776	188568	220218	223385	232263	245398
Architectural Industry	1924	3679	5099	4081	4904	4764
Transport, Postal and Telecommunications Service	4665	7022	8083	8127	8589	8410
Residential Living	14859	38092	45357	53950	54176	49673

Source of the data: *Statistical Yearbook of Urumchi (2000).*

• Prices of electricity

The prices of all sorts of power consumption in Urumchi are as follows: power for large industries (1-10kV): 0.280 yuan/kWh; power for non-industries or common industries (<1kV): 0.344 yuan/kWh; power for agriculture: 0.180 yuan/kWh; power for residential living: 0.387 yuan/kWh; power for non-residential lighting: 0.374 yuan/kWh; power for business and service: 0.50 yuan/kWh.

• Power situation nearby the selected site

There is 1 power plant of its own in Urumchi Mining Bureau, whose installed capacity is 3.6MW. Moreover, the Bureau is in the reach of the main electric network of Xinjiang (2157.3 MW), which ensures the plentiful power supply.

2.2.2 Water supply facilities

The annual volume of rainfall in Urumchi is 2798 Mm^3, and the total volume of surface water and ground water is 1230 Mm^3, which can basically meet the needs of living and industries. The annual water consumption of industries is 141 Mm^3. There are 7 waterworks in the whole city and some industrial water resources of their own, so that the daily water supply is 593 km^3. The total length of the pipelines of water supply is about 570 km, and the popularity of tap water

consumption is 100%. The basic situation of water supply and consumption in Urumchi is shown in table 2-11.

Table 2-11 Water Supply and Consumption in Urumchi

Year	1990	1995	1996	1997	1998	1999
in the Whole Society						
Comprehensive Production Capacity of Water Supply (10^4 t/day)	27	41	41	54	59	59.3
# Ground Water	18	31	31	36	41	41.3
Total Volume of Water Supply of Year (10^4 ton)	9144	13637	14336	14135	14644	15006
# Water for Production	3480	4893	5004	4803	5116	5111
Water for Living	5564	7949	8522	8522	8690	9266
Population of Water Consumption (10^4)	102.50	144.50	147.89	151.94	154.88	158.92
# non-Agricultural Population of Water Consumption	96.30	117.50	121.53	124.12	128.14	131.01
Daily Volume of Water Consumption for Living (L per capita)	148.72	150.71	157.87	153.67	153.72	159.74
inside the Water Supply System						
Number of Water Works of That Year	4	5	5	5	6	6
Comprehensive Production Capacity of Water Supply (10^4 t/day)	20	27	27	40	45	45.1
# Ground Water	11	17	17	22	27	27.1
Total Length of Water Pipeline of That Year (kW)	282	289	312	320	377	387
Total Volume of Water Supply	6603	11027	11736	11535	12044	12506
# Water for Living	4929	7073	7653	7653	7821	8486
Population of Water Consumption (10^4)	99.50	108.40	111.20	115.24	118.18	124.22
# non-Agricultural Population of Water Consumption	93.90	101.40	104.80	107.42	111.44	116.3
Daily Volume of Water Consumption for Living (L per capita)	135.7	178.8	188.6	181.9	181.3	187.16

Source of the data: *Statistical Yearbook of Urumchi (2000).*

According to the programme of city development, the planned water consumption of 2005 in Urumchi is 800km^3/day. In order to achieve this objective, Urumchi now makes an investment of 200 million yuan to build new waterworks that is planned to put into production in 2001. Thus, up to 2005, the city water supply will be basically kept in balance.

- **Prices of water**

The prices are as follows: water for living: 0.7 yuan/m^3; water for industries: 0.8 yuan/m^3; water for business and service: 1.3 yuan/m^3; water for greenland and fire-fighting: 0.5 yuan/m^3; water for capital construction: 1.9 yuan/m^3.

- **Water supply nearby the selected site**

The two main mines with their own high-quality water resources in Urumchi Mining Bureau

have been incorporated in the municipal system of water supply of the Urumchi City, and other mines are supplied by their own water resources (the daily volume of water supply is 10 km^3). Moreover, all of the 5 mines under the Bureau drain off large quantities of mine-water, and the daily volume of discharge is more than 10 kt. This kind of mine-water can be used for industries with some treatment. Therefore, there are plenty of water resources for industries in this area.

2.2.3 Situation of labor force

At present, the total employees in Urumchi are 800,000, and of whom 730,000 are in the secondary and the tertiary industries. The average wage of employees is 9366 yuan /a. The urban controllable income per capital is 6676 yuan and the urban expenditure per capita is 5184 yuan. The pure income per capita of farmers and herdsmen is 3226 yuan.

2.2.4 Auxiliary facilities such as hospitals and schools

• General situation

Under the direction of the policy of "prospering Urumchi through science and education", Urumchi makes the most of effect of science on the economic growth. In 1999, 198 scientific programmes are carried out, which produces economic benefits of 790 million yuan. There are 73 scientific and technological institutions in the whole city, and more than 20,000 people are engaged in the scientific researches and comprehensive technological services.

Education is all along in the priority of development in Urumchi, and the government always applies itself to accelerating the educational reformation powerfully, strengthening the "9-year compulsory education" continuously, and advancing the accomplishments education roundly. By the end of 1999, there are 10 institutes of higher education (34202 students) and 234 middle schools, primary schools (336620 students in middle and primary schools). The rate of students of the right age enrolled in primary schools is 99.3%, and that of the junior middle schools is 99.2% (in urban) and 98% (in county). The rate of students recruited in regular secondary schools increases from 43% of the last year to 56.7%.

There is stable development in healthy undertaking, and the medical conditions get more improvement. By the end of 1999, there are 195 healthy and medical institutions (including 71 hospitals), 11600 beds and 18000 professional medical personnel (including 7924 doctors).

The institutions of culture, news, propaganda, broadcast, television play and film, together with the mass cultural activities are developing vividly. By the end of 1999, there are 9 art groups of various kinds, 2 public libraries (1150,500 books), 3 broadcasting stations and 4 television centers in the whole city, and more than 85 percent of population can get the broadcasting and television service.

• Situation nearby the selected site

There are 1 hospital and 1 clinic in Urumchi Mining Bureau, which can meet the demands of basic medical treatment and occupational disease prevention of the workers and their families. In addition, there are middle schools and primary schools with rather necessary fittings attached to both Bureau and each mines, which can meet the educational needs of the children in the mines.

2.3 Nature gas in Xinjiang

2.3.1 Resources and production of nature gas in Xinjiang

• Resources of nature gas

Xinjiang is very rich in the resources of oil and nature gas, which are mainly concentrated in the area of Talimu(塔里木) Basin, Hami(哈密) Basin and Zhunger(准噶尔) Basin. Since the period of the "8th five-year plan", Xinjiang has been developing gradually as the resources reserve region with the exploration of nature gas. The total volume of the nature gas resources in Xinjiang is 10000 bm^3, and the proven reserves are 200 bm^3, which makes up 30 percent of that of the whole country. The nature gas supply of the proven reserves can last for 20-25 years, and that of the detailed reserves can last for more than 30 years.

In the period of the "8th five-year plan", the exploration of Zhunger Basin went beyond the northwestern fault zone, and remarkable successes were achieved. The proven possible reserves of oil increased by 298.9 Mt.

Talimu Basin: the proven possible reserves of oil in 5 years are 229.25 Mt (including 38.45 Mt condensate), and that of nature gas is 106.68 bm^3 (including 22.74 bm^3 dissolved gas). The detailed possible reserves of oil are 45.12 Mt, and that of nature gas is 37.692 bm^3.

Tuha Basin: in the period of the "8th five-year plan", 11 oil fields and gas fields were discovered and verified, that is: Qiuling (丘陵), Wenjisang(温吉桑), Miden (米登), Baka (巴喀), Shanle (鄯勒), Pubei (葡北), Tulufan (吐鲁番), Shenquan (神泉), Hongnan(红南) and Qialekan (恰勒坎) oil field and Qiudong (丘东) gas field. The proven possible reserves of oil in 5 years are 167.54 Mt, so that the accumulative reserves of oil in Tuha Basin come up to 191.59 Mt. And the proven possible reserves of nature gas are 24.362 bm^3.

Yanqi (焉耆) Basin: since the exploration was carried on in 1993, 2 oil- and gas-bearing structural belts —— Baolangsumu (宝浪苏木) and Benbutu (本布图) —— have been discovered. The industrial oil and gas flow were obtained in Sangonghe (三工河) Group and Xishanyao (西山窑) Group of Lower Jurassic Series in the well Y1, B1 and Y2, which were drilled respectively in the middle –Baolangsumu Structure, the north-Baolangsumu Fault and the Benbutu Structure.

• Output of nature gas

The present annual productivity of nature gas of Xinjiang is 3 bm^3, which makes up 30 percent of that of the whole country.

Table 2-12 Output and Consumption of Nature Gas in Xinjiang

Unit: 10^4ton, C.E.

Year	1985	1990	1995	1996	1997
Output	72.68	66.49	152.60	184.48	285.26
Consumption	72.53	67.28	153.96	184.22	258.71

Source of the data: *Statistical Yearbook of Urumchi (2000).*

Table 2-13 Ratio of Nature Gas in Total Volume of Energy in Xinjiang

Year	1985	1990	1995	1996	1997	1998
Ratio in Total Volume of Energy %	4.9	3.4	5.5	6.1	8.1	8.3
Ratio in Total Volume of Energy Production %	3.5	2.4	3.6	3.9	5.6	6.2

Source of the data: *Statistical Yearbook of Urumchi (2000).*

• Quality of nature gas

The component of nature gas in Xinjiang is mainly methane, and the content of sulfur and nitrogen is low. The calorific value is more than 35.7 kJ/m^3. The heat value of the nature gas of Tuha (吐哈) oil field, the main gas resource of "western gas transferred to east", is 37.8-42.0 kJ/m^3, and its CH_4 content is 81-83%, C_2H_6 content is 12-15%. The heat value of the nature gas of Talimu (塔里木) gas field is about 37.8 kJ/m^3, and the gas is composed of CH_4, C_2H_6, C_3H_8, N_2 and so on. Before transferred, the matter of C3, C4 (and >4) are extracted and separated as the chemical materials, and an ethylene project will be put into construction soon. In addition, the content of CO_2 in the nature gas of Talimu gas filed is a little higher.

2.3.2 Nature gas pipelines network and future construction programme

• Construction of pipeline network of nature gas

At present, there are 8 pipelines of nature gas in Xinjiang Autonomous Region, whose conveying capacity is 4.4 bm^3 /a, and 3 pipelines built in 1996 are involved. That is: Shanshan (鄯善) –Urumchi Pipeline: 300km, annual conveying capacity is 0.6 bm^3; Tazhong (塔中) –Lunnan (轮南) Pipeline: 310 km, annual conveying capacity is 0.9 bm^3; Lunnan (轮南)-Kuerle (库尔勒) Pipeline: 192.4km, annual conveying capacity is 1.2 bm^3. These have made up the pipeline netting of nature gas that is covering the south edge of Zhunger Basin and the north edge of Talimu Basin.

The gas resource of the main pipeline network begins with the pressure of 3 MPa, and ends with the pressure of 1 MPa.

• Future construction programme

In order to put into effect of the strategy of energy development of "western oil transferred to east, western gas transferred to east", the construction of the pipeline network of oil and gas is now being accelerated. The nature gas-transferring project of Xinjiang- Shanghai, which will be soon put into construction, is 4167 km long. The material of the pipelines is steel, and the diameter is 1118 mm. The pressure is 0.8 MPa, and the original designing annual capacity of conveying is 12 bm^3. The pipelines begin in Lunnan (轮南) of Xinjiang, by way of Kuerle(库尔勒)、Shanshan(鄯善)、Wuwei(武威)、Gantang(甘塘)、Zhongning(中宁)、Jingbian(靖边)、Lishi(离石)、Zhengzhou(郑州)、Nanjing(南京)、Suzhou(苏州), and then end in Shanghai(上海). The range of gas supply is covering the pipeline-plot and the Changjiang (长江) River Delta, with the stable gas supply of 30 years. The project will be put into construction in 2001, be finished in 2003, and supply the gas in 2004. The first-stage designing capacity of gas supply is 12 bm^3 /a, and now it is going to increase to 20 bm^3 /a.

2.3.3 Transportation of the gasification products of the hydrogasification factory

The future hydrogasification factory is selected in the Urumchi Mining Bureau, and the nature gas pipeline of Urumchi begins in Head Petrochemical Factory of Urumchi bordering Urumchi Mining Bureau. Thus, the future hydrogasification factory can be directly incorporated in the city pipeline network of Urumchi.

There are 2 tentative progamme on the connection of the gasification products of the coal hydrogasification into the nature gas pipelines of the "western gas transferred to east": the first is laying a new pipeline (310km) from Urumchi to Shanshan(鄯善) for the special use of transferring the hydrogasification products; the second is making use of the original nature gas pipeline of Shanshan- Urumchi (the diameter is 457 mm, the annual gas supply is 0.6 bm^3), and connecting with the main pipeline of Xinjiang- Shanghai (the pipeline of the "western gas transferred to east") in Shanshan(鄯善).

As for the "western gas transferred to the east", the original designing gas supply of Xinjiang-Shanghai Pipeline is 12 bm^3 a year, which will increase to 20 bm^3 a year finally, and the volume difference is 5 bm^3. Therefore, the synthetic gas from the coal hydrogasification plant can be transferred together with the nature gas as the substitute energy, after the commercialization of hydrogasification technology.

2.4 Town gas in Urumchi

2.4.1 Construction of town gas pipelines

The development of the city gas facilities in Urumchi began in 1974, which was mainly liquid petroleum gas (LPG) before 1990. At present there are 28 LPG stations in the whole city, and the annual supply of LPG is 60 kt. The LPG-consumers are 1308,000, and the popularity of the LPG is 99.8%. The consumption of LPG is mainly for people living, and then for some industrial use. The production and consumption of LPG in Urumchi in past years are shown in table 2-14.

Table 2-14 Production and Consumption of LPG in Urumchi

	1990	1995	1996	1997	1998	1999
LPG						
Total Volume of LPG Supply (ton)	32793	50454	48626	52698	52237	59802
# Family Consumption	30567	47619	45106	48814	48877	55114
Population of LPG Consumption (10^4)	83.5	117.2	120.2	122.8	124.7	130.8

Source of the data: *Statistical Yearbook of Urumchi (2000).*

The nature gas project of Urumchi was put into construction in 1990, and the principal part of the project was completed and began to supply gas in 1997. Now the main pipeline netting has been completed in the urban area, and the total length of the main pipelines is about 250 km. Most of the pipelines are steel pipes with medium-pressure, and parts of them are made of plastic materials. The nature gas of that project is from Tuha (吐哈) oilfield and transferred to the urban area through Dawanxiang (大湾乡) Station in the gas pipeline of Tuha oilfield-Urumchi.

The pipeline network systems for conveying and distributing gas use the high- and medium-pressure ones. The present pipelines of high-pressure are 28 km long with pressure of 8 kg, while the pipelines of medium-pressure are 200km long with pressure of 3 kg. There is a store gas station in the north of Urumchi. It has 4 gas spheres of 2000 m^3 with the total storage of 9600m^3, which are used as the gas resources for adjustment. Moreover, something odorous is added into the store gas station (that is, the consumers' gas regulator) to prevent the gas leakage and insure the safety during the course of gas usage.

2.4.2 Consumption of nature gas

• Consumers and the volume of consumption

Nature gas in Urumchi is mainly used for people living, then for business and services, and partially for industries. According to the programme of gas consumption, the number of families of gas consumption should be 250,000. Now, 80,000 families have been installed with the equipment, and about 40,000 families have been able to use the gas. It's planned that the volume of gas supply will be 30 Mm^3 /a by the end of 2000. When all of 250,000 families are able to use the gas in 2005, the volume of gas consumption will be up to 70 Mm^3 /a (including 40 Mm^3 for people living). The long-term goal is that the number of families of gas consumption will be up to 340,000, and total volume of gas supply will come to 185 Mm^3 a year.

At present, a much larger consumer of nature gas is the gas stations for automobiles. There are more than 1000 reequipped automobiles in the whole city which are using nature gas now, and their gas consumption is about 5 Mm^3 a year. In addition, there are some hotels, restaurants and sporadic consumers consuming nature gas.

The burning equipments for nature gas are mainly stoves for both home and restaurants, and boilers.

• Prices of nature gas

The prices of all sorts of gas consumption are as follows: in the store gas stations: 0.70 yuan/m^3; gas for residents: 1.35 yuan/m^3; gas for higher schools' dining room: 1.5 yuan/m^3. The price for industries and business is a little higher, which is 1.8 yuan/m^3 for business and catering trade.

2.5 Situation of coal chemical industries

The coking plants with a certain scale in Xinjiang are all located nearby Urumchi, which are as follows: Coking Plant of Bayi (八一) Iron and Steel Limited Corporation with the capacity of 520kg coke: high temperature carbonization process is adopted; the by-products are coke-oven gas and coal tar and the products are mainly sold to Bayi Iron and Steel Corporation. Coking Plant of Aiweiergou (艾维尔沟) Mine: the designing capacity is 200 kt /a; the process is relatively simply; the coke is mainly sold to Bayi Steel and Iron Corporation and the local iron and steel enterprises. In addition, there are some coking plants with a small scale scattered in Fukang (阜康) and Akesu (阿克苏). The characteristics of these coke products are: low sulfur, low phosphorus, high heat

value and high strength. The market prices vary between 300 and 500 yuan per ton according to different quality.

There are 3 main factories of synthetic ammonia in the Autonomous Region, that is, Head Petrochemical Factory of Urumchi, Xinjiang Chemical Fertilizer Factory, Zepu (泽普) Petrochemical Factory. The total productivity of synthetic ammonia is 940 kt a year, and the products are all used for the production of urea.

Head Petrochemical Factory of Urumchi: it was built in 1975 and put into production in 1980. Now it consists of an oil refinery with annual processing capacity of 500 tons crude oil, a synthetic ammonia factory. The production of synthetic ammonia has 2 sets of equipments fed by two kinds of feedstocks: one is heavy oil, the other is nature gas. The second chemical fertilizer factory, which uses nature gas as the raw material, adopts Brown Technology of the USA to produce synthetic ammonia of 300 kt and urea of 520 kt. The nature gas is mainly from Tuha (吐哈) oil – and gas-field, and transferred to the fertilizer factory directly through the gas pipeline of Tuha-Urumchi. In addition, the annual output of synthetic ammonia in Xinjiang Chemical Fertilizer Factory is 60 kt, and that in Zepu(泽普) Petrochemcial Factory is 280 kt. Since synthetic ammonia is the intermediate product of the chemical fertilizer, its selling price is unable to estimate.

At present, the chemical fertilizer factories in Urumchi, which used coal as raw material, are all closed because of the large energy-consumption, high cost and serious pollution.

2.6 Utilization of by-products of hydrogasification factory

At present, there is little aromatic compounds in the petrochemical products in Xinjiang. Only diethyl benzene, which makes up 40 percent of the total volume of aromatic products, can be used for polyester process in Head Petrochemical Factory of Urumchi, and other products mainly sell in the interior with a stable market. The market price of the products of benzene series is about 3000 yuan / t.

The future development of petrochemical products in Xinjiang is to increase the production of aromatic compounds, build the project of the ethene-based materials for the large-sized organic chemical engineering bases in accordance with the project of "western gas transferred to east", and carry on synchronously the exploitation and utilization of petrochemical downstream products based on refined chemical engineering products. The by-products of coal hydrogasification can not only make up for the shortage of the aromatic resource, but also produce the organic chemical products (such as styrene, phenol and acetone) together with such products as ethene, to provide the basic material for the development of the other products. Thus, the by-products of hydrogasification are of great significance to advance the development of the petrochemical products in Xinjiang Autonomous Region. Otherwise, the production capacity of the by-products is a key influencing factor.

2.7 Summary

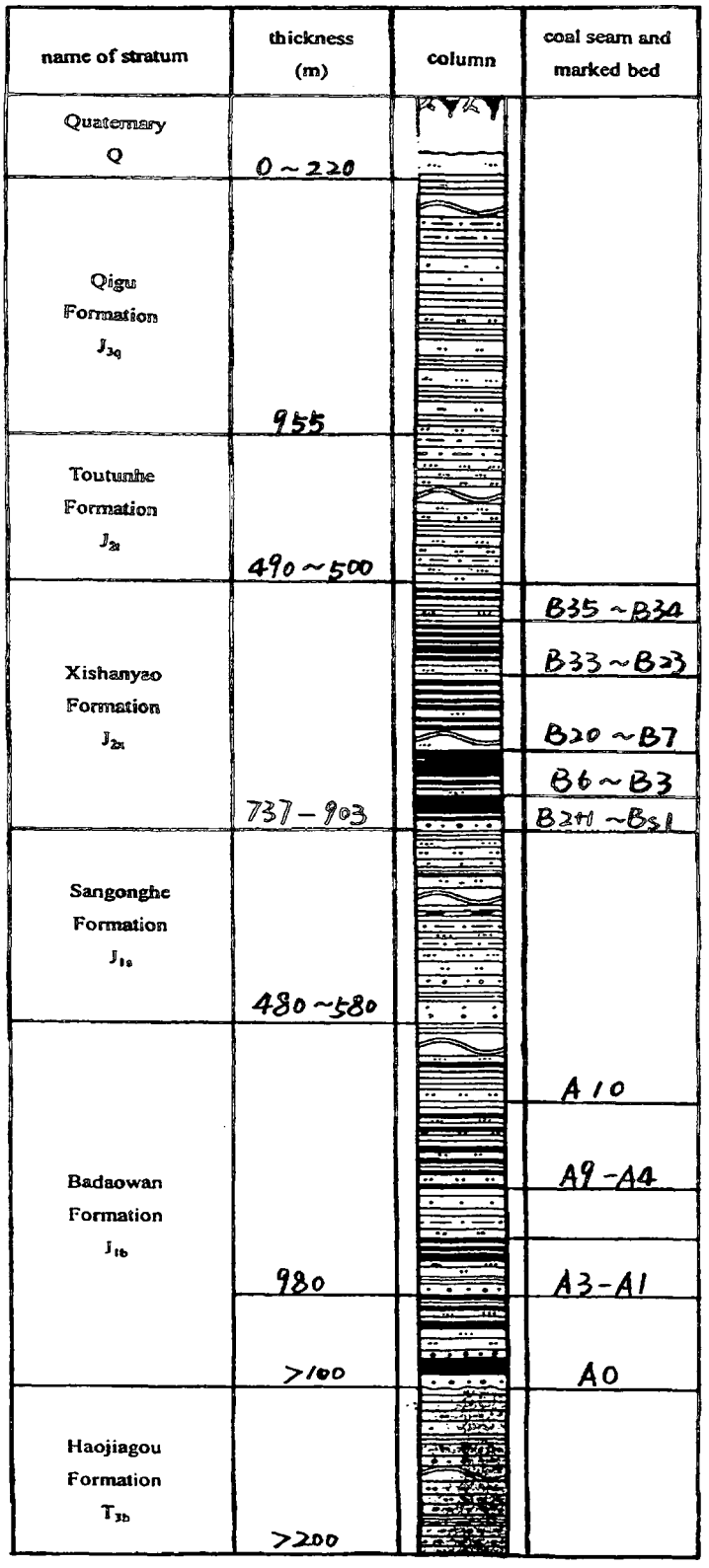
According to the comprehensive investigation to the basic facilities, coal resources and pipeline network construction of the city gas in Urumchi and the area nearby the site selected for hydrogasification, and the on-the-spot investigation by Japanese delegation in Xinjiang, it is believed that in the site there are plentiful coal resources which are suitable for hydrogasification

with a long-term and stable supply, the pipeline networks of gas conveying and distributing which have been built, are being built and plan to be built, and the well-equipped municipal facilities in Urumchi of Xinjiang Autonomous Region. All these provide dependable guarantee for the hydrogasification technology to put into effect.

So, it is feasible to select Urumchi of Xinjiang as the site for the construction of the coal hydrogasification factory.

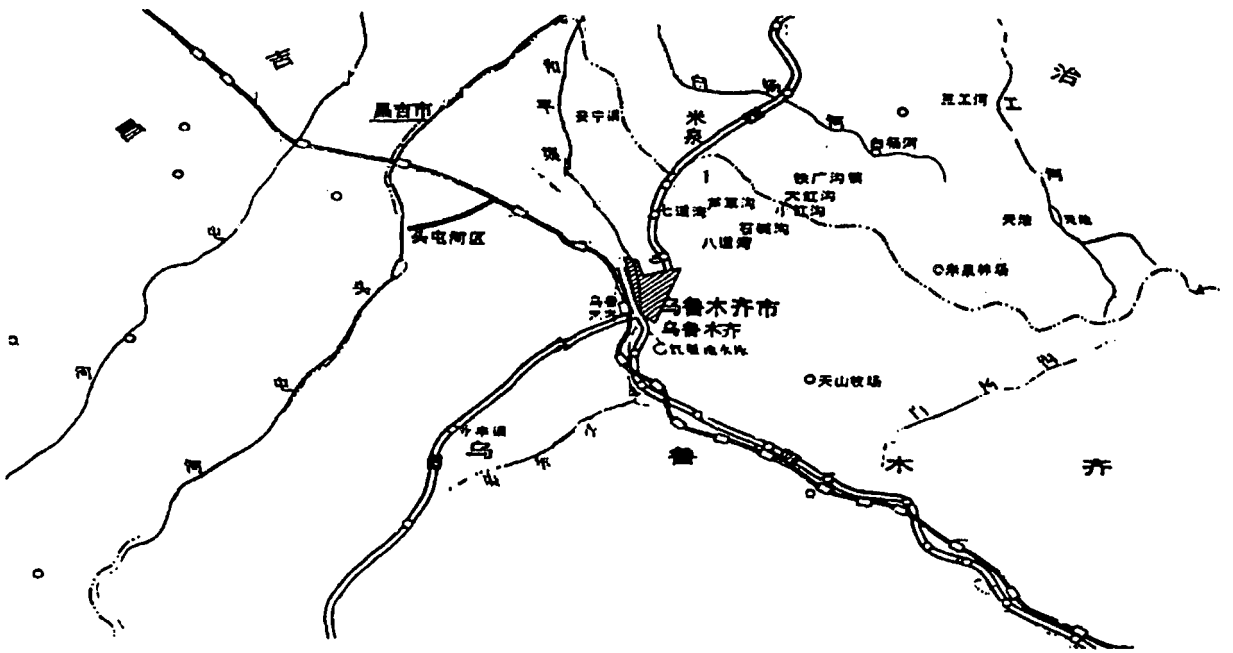
Attached Figure

Comprehensive Columnar Chart of Coal-bearing Stratum (Urumchi Mining Area)



Attached Figure

Candidate Site for Hydrogasification Factory —— Urumchi



note: 1 in the map is Urumchi Mining Bureau, which is just the site selected for the hydrogasification factory

3 Datong, Shanxi

3.1 General situation of Datong and selection of a site for building the factory

3.1.1 General situation of Datong

• General situation of the city

Datong（大同） is located in the north of Shanxi（山西） province from east longitude 112°34′ to 114°32′, and north latitude 39°8′ to 40°44′. Datong is an important city in the place where three provinces (Shanxi, Inner Mongolia and Hebei) meet. It is bounded on the north by Inner Mongolia（内蒙古）, on the east by Hebei（河北）, and on the south by Shuozhou（朔州）City and Xinzhou（忻州）City in Shanxi. There are 4 districts and 7 counties directly under the Datong City, and the whole area is 14112 km^2. Datong has a population of 2,848,000, of which, planned developing districts has a population of 700,000. The number of employee in the whole city is 1,520,000, of whom 880,000 is in the city and towns while 640,000 is in the countryside.

Datong is one of the national famous cities of history and culture published by the State Council and has a long history of almost 2300 years. Today, there are 318 preservation units of cultural and historical relics in the Datong City, including 6 national units, 30 provincial units. Besides these, there is also a national region of historical relics and scenery. The world famous beauty spots, such as Yungang Grottoes（云冈石窟）、Jiulong Wall（九龙壁）、Huayan Temple（华严寺）、Shanhua Temple（善化寺）、Heng Mountain（恒山）and Xuankong Temple（悬空寺）, make up the tour region with distinctive features.

The climate in Datong is temperately continental monsoon climate with distinct seasons. The winter is cold、arid and long while the summer is warm and short, and the rainfall is concentrated. The average air temperature of a year is 6.8℃, and the average annual precipitation is 417.3mm. The dominant wind within a year is the north wind and northwest wind. The average wind velocity is 2.9 m/s, and the maximum velocity is 3.4 m/s.

The characteristics of the Datong City are defined in the city overall plan as: the national historical and cultural city; the main city of coal-energy; the center city in the place where three provinces (Shanxi, Inner Mongolia, Hebei) meet. The planned structure of the Datong City is "one center and two groups", that is, the urban is the center, and the east group (Wenying District，文瀛区) and the west group (Kouquan District，口泉区) are relatively independent but connected with each other.

• Traffic situation of Datong City

Datong is located in the place where the east China and the middle-west China meet, which has favourable conditions of connecting the east and entering the west China. It is not only the central city where 3 provinces meet, but also an important key link of the northwest and the North China. 4 railways (Jing—Bao，京包，Da—Qin，大秦，Tong—Pu，同蒲，and Jing—Yuan，

京原) cross the whole city. Jing—Bao（京包）railway and Tong—Pu（同蒲）railway meet at Datong, and Da—Qin（大秦）electric railway can get to Qinghuangdao（秦皇岛）dock directly from Kouquan（口泉）. Datong is 385 km away from Beijing, 433 km away from Baotou（包头）, and 370 km away from Taiyuan（太原）. Moreover, there are more than 40 feeder railways and special lines.

97% the volume of rail freight in Datong Railway Bureau is coal transportation. Kouquan（口泉）Railway Station is the largest freight loading station in the country, and Datong Railway Station is one of 38 main marshalling stations in countrywide railways. Besides Datong Mining Bureau, there are 53 stations or places for coal transportation in the city (including 25 coal stations of full trains), and the total loading capacity is 60Mt. The annual volume of rail freight is more than 35Mt, and the annual volume of coal transportation by train accounts for about 55% of Datong coal production.

National Road 109 (from east to west) and National Road 208 (from north to south) meet in Datong. In addition, there are more than 10 arterial roads in the city, in which 6 roads get to the other provinces, that is: Da-Tang（大唐）, Da-Lai（大涞）, Shuo-Wei（朔蔚）road lines to Hebei province, Da-Zhang（大张）road line to Beijing、Tianjin（天津）、Tangshan（唐山）, and Tong-Feng（同丰）, Yun-Feng（云丰）road lines to Inner Mongolia. The volume of coal freight by road lines makes up 16% the output of the coal.

Therefore, compared with the other coal bases in the west of China, Datong still has favourable conditions in regional competition.

• Economic situation of Datong

Datong is located on the important key link of transportation where the economic districts of the round Bohai Sea gulf and the Northwest economic district meet. Today, there has been the complete industrial system in Datong, taking coal industry as basis, power generation and chemical industry as core, meanwhile including many other departments, such as building materials, machine building, medicine, food and textile industry. In 1999, the GNP of the whole city is 16.81 billion yuan(RMB), and the GNP per capita is 5907 yuan. The production value per capita in the whole city is 11059 yuan. The ratio of the agriculture, industry and tertiary industry is 5.7: 53.5: 40.8. The consumption level of the residents per capita is 2011 yuan, and the controllable income per capita is 4437.7 yuan.

There are 418 industrial enterprises with a certain scale in Datong, in which there are almost 300,000 workers, and the value of the fixed assets is 24 billion-yuan. The increase value of the industry in the whole city is 5.985 billion-yuan in 1998.

The structure of products and the main economic indexes, the main industrial indexes and the output of main industrial products are respectively shown in table.3-1, 3-2 and 3-3.

Table 3-1 Main Economic Indexes and GDP of Datong (1997)

Unit: 10^4yuan

Total Output	Primary Industry	Secondary Industry	#Industry	Tertiary Industry	#Communication and transportation	#Wholesale and retail sale, Catering trade
3 720 711	243 372	2 520 721	2 204 485	956 618	392 945	229 224

GDP	Primary Industry	Secondary Industry	Tertiary Industry
1 556 877	137 474	895 201	524 202

Source of the data: *Statistical Yearbook of Shanxi Province (1999).*

Table 3-2 Output of Main Industries Products (1997)

Total Output of Industry	Raw Coal	Electricity	Steel	Steel Products	Coke	Cement
(10^4 yuan)	(10^4 ton)	(10^8 kWh)	(10^4 ton)	(10^4 ton)	(10^4 ton)	(10^4 ton)
1 563 294	8 083	80.02	18.11	1.97	96	204.01

Source of the data: *Statistical Yearbook of Shanxi Province (1999).*

Table 3-3 Total Output Value of Farming , Forestry ,Animal Husbandry and Fishery(1997)

Main Economic Indexes	Total Output value	Output Value of Farming	Output Value of Forestry	Output Value of Animal Husbandry	Output Value of Fishery
10^4 yuan	243 372	153 973	7 841	81 128	430

Output of Main Agriculture Products	Total Products of Meat		Total Products of Grain		Total Products of Rapeseed	
	(1997)	Pork	1996	1997	1996	1997
(ton)	67 851	51 412	771 000	552 986	55 108	28 301

Source of the data: *Statistical Yearbook of Shanxi Province (1999).*

In recent years, with the adjustment of the industrial structure, Datong City has formulated the developing policies: to develop potential products based on the market demand, support financial reformation and technical innovation, train enterprisers with creative mind, promote the reformation of traditional industry and the development of new industry, accomplish the rationalization of the industrial structure. The potential projects involve: the construction project of 1Mt of Coal Water Slurry (CWS) in Datong Coke Company; the project of 10Mt of coal preparation; the project of alloy iron products from new techniques in Guangling Chemical Industry Company; the project of 1000 tons of $Al_2(SiO_3)_3$ refractory fiber textiles from refuse in Datong Special Refractory Material Ltd,Co.; the project of graphite electrode of super strong power in Datong Carbon Factory and so on. Since 1995, the investment of fixed assets in the whole city has amounted to 14.14 billion yuan. The major construction projects of city and locality under the city are: the project of 300,000 tons of steels-melting engineering in Datong Steel Factory; the project of special railway line in Wangjiapu（王家堡）; the project of the gold mine in Yanggao（阳高）, the project the route change of National Road 208; the project coal gas engineering in Yungang（云冈）Coking Factory.

In 1999, the volume of foreign trade of the whole city was 26.59 million US dollar, and the volume of export was 15.79 million US dollar, the volume of importation was 10.80 million US dollar. By the end of 1999, 114 foreign capital enterprises have registered in Datong.

Datong City is famous for its tourism. In 1999, about 35,700 foreigners and 37,600 people from Hongkong、 Macao and Taiwan came to Datong. The foreign exchange earnings from tourism were 10.505 million US dollars. Now the tourist trade has been one of the most potential industries in Datong. The tour income of this year is estimated to 350 million yuan, which will accomplish to increase by 100 million yuan.

For historical reasons, there has been a unitary industrial system in Datong. Datong's economy is influenced by energy market greatly. In these two years, due to the weakening coal market, the financial income is not satisfactory. In 1999, the financial income of the whole city was 1.402 billion yuan, which was 8.15% less than the last year. The estimated income is 0.931 billion yuan, and the estimated expenditure is 1.377 billion yuan, of which the expenditure for scientific undertaking, administration expenses and retirement expenses has increased, and the estimated expenditure is 0.236 billion yuan more than the estimated income.

• Present situation and demands of energy in Datong

Datong is well known as "the capital of coal" and it is very rich in coal resources. Datong is one of the major cities of energy export, whose energy structure and economic structure are based on coal. The gross output value of energy industries makes up about 60% the gross output value of the whole industries.

①Situation of energy industries

The production, conversion and utilization of coal energy are always dominant in the economic structure of Datong, and they are also very important in the local economy. The exploitation and utilization of coal and its ratio in the gross value of economy are shown in table 3-4 (from 1978 to 1997).

Table 3-4 Exploitation and Utilization of Coal and Its Ratio in the Gross Value of Economy (1978～1997)

Year	Output (10^4 ton)	A%	B%	Year	Output (10^4 ton)	A%	B%
1978	2926	62.75	70.14	1988	7066	54.88	69.95
1979	3241	62.91	70.08	1989	7604	54.82	70.09
1980	3581	62.44	68.77	1990	8043	56.49	70.62
1981	3955	64.01	70.85	1991	8030	54.00	68.44
1982	4301	63.31	70.30	1992	7796	52.26	66.77
1983	4695	62.18	69.33	1993	8266	51.06	63.56
1984	5519	61.58	68.62	1994	8142	48.16	61.23
1985	6170	61.50	71.28	1995	8158	45.75	57.70
1986	6545	59.12	70.28	1996	8606	47.11	60.39
1987	6848	56.83	70.05	1997	8083	45.91	59.12

Notes: A%—the ratio of the output value of coal mining and preparation to the gross output value of industries in that year.

B%—the ratio of the output value of coal mining, preparation and conversion to the gross output value of industries in that year.

Source of the data: *Statistical Yearbook of Shanxi Province (1999).*

Coal industry is the economic lifeblood of Datong. In these years, the national taxes of coal take up 60% of the national taxes of the whole city, and the local taxes of coal take up 57% of the local taxes of the whole city. The output value of coal takes up 47% of that of industries of the whole city, while the profit tax of coal takes up 59% of that of industries of the whole city. Among ten of the largest industries in Datong, except coal industries, the ratio of total output and gross value of assets of the other industries is less than 10 percent. The number of staff and workers in coal industries or other industries interrelated to coal is more than 500,000, and the annual benefit from coal industry is more than 10 billion yuan.

The power system of Datong is very important component of the power system of Shanxi province. It is an important thermal power base and the largest load center in the north of China, and it's also an important pivot of the electrified wire netting of the North China. At present, there are 8 power plants in the whole city. The total installed capacity is 1,4495 million kW, and the maximum annual production of electric energy is 9.092 billion kWh. This system supplies power energy not only to this locality, but also to the region of "Jing-Jin-Tang"(北京、天津、唐山). The total production of electric energy in 1996, 1997 and 1998 is respectively 8.95122, 8.00052 and 9.09154 billion kWh.

②Situation of energy demands

The annual consumption of coal in Datong is about 13.8Mt. The coal consumption in power industry and chemical industry is more than that in other industries and the ratios of coal consumption in power industry and chemical industry is respectively 36% and 33%. Among the civil consumption of coal, there is a certain proportion of scattered boilers with a small scale and strong pollution. The consumption of major energy is shown in table 3-5.

Table 3-5 Consumption of Major Energy and Raw Materials (1997)

Raw Coal (ton)	Coke (ton)	Electric Power (10^4 kWh)	Steel (ton)	Cement (ton)	Pig Iron (ton)
7 371 892	310 250	436 247	153 187	320 721	6 725

Source of the data: *Statistical Yearbook of Shanxi Province (1999).*

The annual volume of coal conversion in Datong is about 7Mt and the major coal products are primary products, with little additional value. Besides electric energy production, the patterns of coal conversion are mainly gasification and charcoal material production, where the coke is produced with high-quality coal of Jurassic Period, then many products, such as alloy iron, calcium carbide, synthetic ammonia and electrodes, are produced from the coke.

• Environmental situation of Datong

In these years, a certain effect has been made in the comprehensive control of the environment of the city, and the environmental quality has been improved considerably. As a base

of heavy industry with concentrated resources and serious pollution, however, Datong is still backward in environmental quality. At first, there is a shortage of water resource, and the surface water and the groundwater are polluted seriously. Then, there is noise pollution and serious air pollution which is mainly caused by waste gas, pollutants from burning and powdered-coal, and tail gas released by all kinds of motor vehicles. In addition, the smoke released by catering and civil stoves can also cause serious air pollution. With the development of the industry and the quickening of the rate of the urban construction, the coal consumption in Datong is increasing at a rather high rate. According to the statistical data of environmental protection of these years, the coal consumption of Datong in 1985, 1990 and 1995 is respectively 3.98, 6.79 and 7.78Mt. The pollutants caused by coal-burning respectively are: in 1985, smoke dust: 4.1×10^4 ton, industrial dust: 8.9×10^4 ton, SO_2: 5.2×10^4 ton; in 1990, smoke dust: 4.4×10^4 ton, industrial dust: 7.8×10^4 ton, SO_2: 8.9×10^4 ton; in 1995, smoke dust: 5.5×10^4 ton, SO_2: 10.9×10^4 ton, industrial waste gas: 7.66×10^{10} m^3. Among these pollutants, the discharge volume of industrial dust has decreased because the control of the smoke and dust has been strengthened in these years, while the discharge volumes of the other two kinds of pollutants are increasing. There are mainly 7 industries that cause pollution: the first is excavation industry, and then is construction material industry, chemical industry and so on. The ratio of the discharge volumes of waste gas, smoke dust, industrial dust of these 7 industries to the total discharge volumes of the whole city is respectively 94%, 89.4%, 100%. In 1998, the main pollutants of Datong are SO_2, suspended and dust. The average daily discharge volume of SO_2 and suspended is respectively 117 mg/m^3 and 594 mg/m^3, and the average daily volume of dust is 32.07 ton/km^2, which is 0.6 ton/km^2 more than that in 1997. According to the environmental supervision, it is the typical pollution of coal-smoke model that the main pollutants in the air are suspended, SO_2 and NO_x. Among these pollutants, the pollution caused by SO_2 is the most serious.

- **Present problem and future development programme**

①Present problem

The inappropriate structure of products and the low extra value: The sales of raw coal have held a dominant position in Datong for many years. The products with a certain brand are not formed, so the extra value of the products is very low.

The low level of administration and the serious waste of production: At present, the lax administration, the inappropriate rules and regulations and the weak basic work in some enterprises cause a high consumption of material and energy.

The backward patterns of burning and the serious air pollution: The energy structure of Datong is based on raw coal burning, and coal burning takes up about 99% of the total energy consumption of the whole city. The energy consumption for industry and for people living are both in traditional and backward ways, such as raw coal burning and decentralized production and offering by heat system, which causes serious environmental pollution.

The serious piling up and slow pace of administration of waste materials: The waste

materials are mainly refuse and fly ash, which take up 80% of the total volume, and the rest are cinder, domestic garbage and so on.

②Future development programme

According to the present situation of large proportion of energy industry, low technological content, extensive management and the lack of aftereffect, Datong has put forward the developing strategy — improving the utilization efficiency of coal, decreasing the environmental pollution and promoting the economic development. The programme involves: improving the coal quality; quickening the local conversion of coal; decreasing the environmental pollution; promoting the economic development; transforming the old unitary pattern of selling raw coal to selling clean coal products which is suitable to market demands; taking coal gasification as the precursor, C_1 chemical industry as the core to construct coal conversion bases for forming the new pillar industry; taking part gasification of coal as the precursor, the comprehensive utilization of oil and coke as key point to promote the development of tar chemical industry and acetylene chemical industry; improving the environmental quality of Datong and accomplishing the sustainable development of economy and environment.

3.1.2 Coal resources of Datong

• Advantage in coal resources

Datong is the largest city of coal production in China, which is very rich in coal resources. And the coal in Datong is good material for coal hydrogasification because of its good qualities.

Datong coalfield is distributed over 2 cities (Datong, Shuozhou) and 7 counties. The length of the coalfield is about 80 km, the width is about 30 km, and the area is about 1827 km^2. There are two coal measures: the Jurassic Period and the Carboniferous Permian Period. The total geological reserves of coal are 37600Mt. The coalfield area of the Jurassic Period is 772 km^2, and the reserves are 6800Mt; the coalfield area of the Carboniferous Period is 1793 km^2, and the reserves are 30800Mt (the overlapping area of these two coal measures is 684 km^2). In addition, there are fragmentary coalfields in Hunyuan（浑源）, Guangling（广灵）, Lingqiu（灵丘）and Yanggao(阳高). In Hunyuan, the area of coalfield that has been approved to exploit is 70.352 km^2, and the geological reserves are 544Mt.

Datong Mining Bureau is a key state-own coal mine. Its mining area is 1143km^2, while the area of the Jurassic Period is 88 km^2, and that of the Carboniferous Permian Period is 1055 km^2. By the end of 1998, the total reserves were 3855Mt, and the mining reserves were 2400Mt. The upper Jurassic measure is in the north of the coalfield, and it is tens to hundreds of meter away from the earth's surface. The thickness of the stratum is 324 m, which involves 15 coal seams. The total thickness of the coal seams is 26 m, and the distance between two seams is short. The coal seams in the north of the coalfield belong to 3 coal formations. In the south of the coalfield, there are 10 coal seams with a short distance between two seams. The distance between two coal measures in the north of coalfield is about 100 m, while that between two coal measures in the

south of coalfield is about 200 m. In the southeast of the coalfield, there is a rather big dip angle along the coal seams, and the rest are almost horizontal coal seams, which is simple in geological structure, without complicated folds and large faults. The main coal-bearing stratum in the coal seams of the Jurassic Period, which is mined at present, is low Jurassic Series, Datong Formation, whose thickness is 34 m.

The mining area of the local mines is 632 km^2, and the coal reserves are 4465Mt. There are two coal-contained stratums (the Jurassic Period and the Carboniferous Permian Period) in the range of the mining area. The mining area of the Jurassic Period is 441.78 km^2, and the reserves are 1735Mt; the mining area of the Carboniferous Permian Period is 190.22 km^2, and the reserves are 2730Mt. There are more than 20 coal seams in the low Jurassic Series, Datong Formation, and the main mined coal seam is the 2^{nd}, 3^{rd}, 7^{th}, 8^{th}, 9^{th}, 11^{th}, 12^{th}, 13^{th} and 14^{th} coal seam. The thickness of the coal seams is 16~20 m, and that of the coal-bearing stratum is about 180 m, the coefficient of coal-bearing is about 9%. The thickness of coal-bearing stratum in the Carboniferous Permian Period, Shanxi Formation and Taiyuan Formation is about 13.2 m, which involves 18 coal seams, and the mined coal seam is mainly the 2~3, 5^{th}, 9^{th} coal seam. The average thickness of coal seam is 33m, while the maximum of the thickness is 56m. The coefficient of coal- bearing is 17%.

• Advantage in coal quality

The coal produced in Datong mining area is mainly weakly caking coal of the Jurassic Period, partly non-caking coal. The qualities of the coal are stable, and the main advantages are: low ash, low sulfur content, low aluminum content, appropriate volatile matter, high calorific value, low Ca、K、Na content, low ash fusibility and so on. The ash ranges from 6% to 21%, and in the same coal seam the regularity of ash is high → low → high toward the southeast along the coal measure. The volatile matter ranges from 28% to 34%, increasing from center to edge horizontally. The total sulfur content in all the coal seams ranges from 0.5% to 2.5%, and most of it is lower than 1.5% while the sulfur content is quite higher in the 12^{th} and 14^{th} coal seam. Gross calorific value (dry ash free basis) of the coal is about 7800 kcal/kg (32.62 MJ/kg), and net calorific value (as received basis) is about 6700 kcal/kg (28.02 MJ/kg). In the northwest of the mining area, the calorific value is a little lower because of the higher total moisture content. The caking property of Datong coal is in little change. The maximum thickness of plastic layer (Y) is always 0. The caking index is almost less than 10. The characteristic index of clinker ranges from 1 to 5. The production ration of coal tar is always less than 9%. And the washability of Datong coal is much better.

The data of coal-quality are show in table 3-6 and table 3-7.

The comprehensive columnar chart of coal-containing stratum is shown in figure.

Table 3-6 Coal-Quality of Coal Seams in Datong Mining Area

Name of coal seam	Thickness of coal seam min-max/average (m)	Distance between seams (m)	Structure	Stability	Coal Class	coal-quality			
						Ash A_d(%)	Volatile matter V_{daf}(%)	Sulfur $S_{t,d}$ (%)	Calorific Value $Q_{net,ar}$(cal/g)
2	0.10～4.46/3.00	—40—	simple	Stable	weakly caking coal	10～20	30～34	0.5	7800～8100
8	0.05～1.75/1.20	—15—	simple	Moderate stable	weakly caking coal	10	29～33	1.6～1.9	8000～8200
9	0.05～2.08/1.00	—20—	simple	Stable	weakly caking coal	5～11	30	1.1～1.2	7900～8100
11	1.11～5.06/2.00	—3—	simple	stable	weakly caking coal	10	29	0.47	8000
12	0.11～4.33/2.00	—4—	simple	stable	weakly caking coal	10～17	28	0.40	8000
14	1.00～4.00/2.50		moderate	stable	weakly caking coal	10	27～29	0.50	7950
山-1～5	0～3.80 6.0～25.0/12	—20— —3—	simple complicated	unstable Moderate stable	gas coal gas coal	29～33 30	39～40 33～40	0.4～0.7 0.3～0.7	 8100
6～7	0～6.50/2.00	—26—	simple	unstable	gas coal				
8～9	0.13～19.0/6.50		complicated	Moderate stable	gas coal	14～36		1.6～2	8000

Source of the data: *Assembly of Materials of Coal Quality of Datong Mining Bureau.*

Table 3-7 Coal-Quality Data of the Major Mines in Datong Mining Area

Name of Mines	M_{ad}%	A_d%	V_{daf}%	CRC	$S_{t,ad}$%	$Q_{gr,ad}$ MJ/kg
Majiliang(马脊梁矿)	7.17	14.02	32.53	1-2	0.33	25.99
Wangcun(王村矿)	5.56	10.27	33.09	2	0.25	27.27
Yanzishan(燕子山矿)	4.16	7.90	32.25	1-2	1.21	28.92
Sitai(四台矿)	4.77	13.02	32.43	1-3	0.70	27.31
Meiyukou(煤峪口矿)	4.51	7.19	28.37	2-3	0.30	29.97
Yongdingzhuang(永定庄矿)	3.11	6.78	27.88	2-3	0.36	31.06
Tongjialiang(同家梁矿)	2.07	10.74	28.68	3	0.99	29.73
Silaogou(四老沟矿)	5.57	10.01	28.82	2-3	0.82	27.83
Xinzhouyao(忻州窑矿)	2.71	10.80	25.14	2-3	0.80	29.60
Baidong(白洞矿)	3.27	8.03	29.18	2-3	0.86	30.28
Yanya(雁崖矿)	2.54	7.12	26.12	3	0.26	30.05
Kongjinwan(控金湾矿)	6.11	12.98	30.78	2-3	0.90	26.64
Jinhuagong(晋华宫矿)	3.36	11.86	30.44	1-3	0.62	28.72
Dadougou(大斗沟矿)	3.62	6.57	31.53	2-3	0.56	30.24
Yungang(云岗矿)	4.47	8.37	30.57	2-4	0.68	29.64

Source of the data: *Assembly of Materials of Coal Quality of Datong Mining Bureau.*

• Advantage in output and varieties of coal

The total output of coal in Datong takes up 1/16 of that all over the country, and 1/4 of that in Shanxi province. The volume of Dating coal sales in other provinces takes up 1/5 of inter-provincial sales all over the country and 1/4 of Shanxi province. The volume of coal export takes

up 1/3 of that all over the country and half of that in Shanxi province. The raw coal output of Datong in 1996, 1997, 1998, 1999 is respectively: 86.07, 80.83, 69.51, 55.68 Mt. The volume of Datong coal sales in other provinces is respectively: 68.9719, 66.0859, 55.2506, 25.9983 Mt. The volume of export in 1996, 1997, 1998 is respectively 4.6051, 4.629, 2.4088 Mt. Up to the August of last year, there were at least 630 mines in Datong, and the annual coal production is 81 Mt.

In Datong Mining Bureau, there are 15 production mines in which there are 16 pairs of mines, and the original designing production capacity is 16.6Mt. Owing to the technological reformation and the constant development of mechanization of coal mining, the actual coal production in 1999 is more than 40Mt, the actual output of raw coal is 29.59Mt, and the sales volume of commodity coal in other area is 29.14Mt. The level of mechanization is up to 97.05%. There are 3 coal preparation plants for power coal in Datong Mining Bureau. The original designing annual washing capacity of preparation plants in Yanzishan Mine, Sitaigou Mine, Yangan Mine is respectively: 4.5, 5.3, 4Mt, and the actual annual washing capacity is respectively: 3, 2.7, 3Mt. The major products are washed mixed coal, washed slack coal, washed lump coal, screened lump coal and so on.

Table 3-8 Production of Datong Mining Bureau

Name of Mines	Mined Coal Seam	Designing Productivity of Mines, $\times 10^4$ton	Time of Putting into Production	Coal Class	Output of Raw Coal (1999) $\times 10^4$ton
Total		1660			2959.01
Meiyukou(煤峪口矿)	12	90	1957	weakly caking coal	170.96
Yongdingzhuang (永定庄矿)	8	120	1963	weakly caking coal	100.42
Tongjialiang(同家梁矿)	13	120	1968	weakly caking coal	248.60
Silaogou(四老沟矿)	12	150	Dec. 1960	weakly caking coal	228.23
Xinzhouyao(忻州窑矿)	10	90	Oct. 1957	weakly caking coal	136.57
Baidong(白洞矿)	10	90	Dec. 1958	weakly caking coal	62.14
Yanya(雁崖矿)	6	90	Jun. 1962	weakly caking coal	131.11
wajinwan(挖金湾矿)	11	120	1960	weakly caking coal	124.15
Jinhuagong(晋华宫矿)	25	120	1959	weakly caking coal	189.09
Majiliang(马脊梁矿)	10	15	1973	non-caking coal	270.12
Dadougou(大斗沟矿)	3	45	1961	weakly caking coal	56.58
Wangcun(王村矿)	11	60	Mar. 1970	non-caking coal	119.08
Yungang(云岗矿)	11	150	Mar. 1973	weakly caking coal	256.01
Yanzishan(燕子山矿)	10	400	Sep. 1980	non-caking coal	220.09
Sitai(四台矿)	11	500	Dec. 1991	non-caking coal	270.52

Source of the data: *Assembly of Materials of Coal Quality of Datong Mining Bureau.*

There are 600 local mines in Datong in August 1999, and the actual annual coal production is 48Mt. According to the ownership: 2 mines directly under the city; 12 pits under the mines; 40 mines under the counties; 2 mines under the Light Industry Bureau; 539 mines under village and township groups. According to the administrative districts, 7 mines directly under the city; 12 pits under the mines; 213 mines under Nanjiao(南郊)District; 164 mines under Zuoyun(左云)County;

84 mines under Hunyuan（浑源） County; 49 mines under mining area; 28 mines under Xinrong（新荣）District; 19 mines under Lingqiu（灵丘）County; 12 mines under the city district; 6 mines under the Guagling（广灵） County; 2 mines under Datong County; 2 mines under Yanggao（阳高）County; 1 mine under Tianzhen（天镇）County; 1 mine under the Judicial Bureau of Datong. The local mines have mainly depended on the direct sales of raw coal in these years, and have not any product with a certain brand that can meet the consumers' demands.

• **Advantage in coal prices**

At present the selling price of different kinds of coals in Datong respectively is: mixed coal: 80-90 yuan per ton; lump coal: 112 yuan per ton. And the ex-mine price of Datong Mining Bureau respectively is: mixed coal: 110 yuan per ton; lump coal: 130 yuan per ton.

3.1.3 Sites selection for hydrogasification

Datong is one of major bases of power coal in our country. It is very rich in coal resources, and the coal quality is fine. The municipal construction of Datong is well equipped, and the enterprises of coal production and processing are much popular. So, it is very suitable to select Datong as the site for coal hydrogasification. In view of the present situation of coal production and municipal construction, we have carried out discussions, together with the personnel concerned of Datong Planning Committee, and selected Coal Gas Factory of Datong as the first site for coal hydrogasification and Nanjiao（南郊）Coal Gas Factory in Luoliwan（落里湾）as the second site.

The sites selected are shown in figure.

3.1.4 Traffic situation and distance to the coal mines

The coal Gas Factory of Datong Coal Gas Company is located on No.1, Kaiyuan（开源）Street, which is in the south of Datong city. It is all the open ground around the factory. The factory is 4 km from Datong Railway Station; 10 km from Datong Mining Bureau, 15 km from the No.1 mine of Datong Mining Bureau and 40 km from the farside Sitai（四台）mine of Datong Mining Bureau. The nearest local mine is about 10 km from the factory. In addition, there are special railways in the factory.

Nanjiao(南郊)Coal Gas Factory in Luoliwan(落里湾)is an enterprise directly under Nanjiao District, which is located in Luoliwan Village, Hanjialing（韩家岭）Town, Nanjiao District of Datong. The factory is 11km from the urban (Datong Railway Station); 8km from Datong Mining Bureau; and there are coal mines 20km away from the factory. Both Tong-Pu（同蒲）line and National Road 208 pass by the factory, and the railway special lines are approved to build. Hanjialing（韩家岭）railway station is near the factory.

3.2 Present situation and future development of public facilities in Datong

3.2.1 Power facilities

The power system of Datong is a major part of the power system of Shanxi province, an important thermal power base and the largest power load center in the north of China. It is also an important pivot of the electrified wire netting of the North China. At present, there are 8 power plants in the whole city. The total installed capacity is 1449,500kW, and the highest annual electricity production is 9.092 billion kWh. The annual consumption of water is 30Mt, and the annual consumption of raw coal is 4.5Mt. The thermal power plants are: the Second Power Plant of Datong (120×10^4kW), the First Power Plant of Datong (21.05×10^4 kW), Hengshan (恒山) Power Plant (2.4×10^4kW) and Guangling (广灵) Power Plant(1.5×10^4kW). The annual electricity production in 1996, 1997, 1998 is respectively: 8.95122, 8.00052, 9.09154 billion kWh. The Power System of Datong mainly supplies power energy to Beijing, Tianjin, Tangshan besides its own locality. So, the power supply of Datong City is plentiful.

3.2.2 Water power facilities

Datong is not rich in water resources, and the daily lack volume of water is about 0.1Mt. But the east of city is not in shortage of water. The water-scanty area is mainly located in the urban, suburban districts, mining area and developing districts.

• Present situation of water resources

The water supply system of Datong is mainly composed of Water Supply Factory of Waterworks, Cetian(册田)reservoir, agricultural wells, Water Supply Company of Datong Mining Bureau and so on. There are 8 water supply factories attached to the city Waterworks, whose total volume of water supply in 1999 is 82.76Mm^3. The volume of water supply from earth-surface water is 58.75Mm^3. In addition, the Water Supply Company in Datong Mining Bureau mainly meets the water needs of the bureau itself.

• Consumption of water resources

The consumption of water resources in Datong mainly involves industrial consumption, agricultural consumption and living consumption. Among these, the total volume of industrial consumption in 1999 is 91.89Mm^3, including municipal works, fire-fighting, green land and so on. The industrial consumers of water consumption mainly are: the Second Power Plant, the First Power Plant, Shanxi chemical Plant, Xinda (新大) Steel Works, the Wheel Factory of Datong Mining Bureau, the Coal Gasification Company, The Chemical Plant of Datong Mining Bureau and so on. The water consumption of the major industrial consumers is shown in table 3-9.

The prices of all sorts of water consumption are as follows: water for living: 1.4 yuan per ton; water for business and service: 1.5 yuan per ton; water for industry: 1.9 yuan per ton.

Table 3-9 Water Consumption of the Major Industrial Consumers in Datong

Name of Enterprises	the Second Power Plant	the First Power Plant	Shanxi Chemical Plant	Xinda Steel Works	Coal Gasification Company	the Chemical Plant of Datong Mining Bureau
daily water consumption(m^3)	30000~40000	500	1600	520	4000	2000

Source of the data: the Committee of City Construction of Datong (1999).

It is shown from above that Datong is a city short of water and is not rich in water resources.

3.2.3 Situation of labor force

The total population of Datong is 2,848,000. The number of employees in the whole society is 1,520,000. Among these, the number of employees in the urban is 880,000, and that in the countryside is 640,000. The GNP per capita is 4814 yuan. The expenditure per capita is 2011 yuan. And the controllable income per capita is 4437.7 yuan.

There are 17,100 unemployed persons registered in the urban by the end of 1999, and the rate of unemployment is 2.36%. The urban household budgetary per capita is 4306 yuan, and the expenditure per capita is 3634.5 yuan.

3.2.4 Situation of auxiliary facilities such as hospitals and schools

By the end of 1999, there are 290 medical and healthy institutions (not including clinics and health care units), 10811 beds and 13919 medical personals. And the medical facilities are well equipped.

There are 5 institutes of higher education, 12 specialized secondary schools, 29 vocational middle schools, 289 regular secondary schools and 2415 primary schools in Datong. The number of students in all kinds of schools is 535,000. The 9-year compulsory education has been accomplished in 8 counties and districts. The rate of students enrolled in primary schools and junior middle schools is respectively 99.7% and 99.1%.

By the end of 1999, there has been 13 libraries, 11 cultural halls, 1 art hall, 1 museum, 11 television stations, 2 medium wave broadcasting launching stations and 10 wired television stations.

In a word, the situation of the basic facilities in Datong is fine. And with the further reformation, the economic development of Datong will take on a new look.

3.3 Present situation and developing program of the city gas in Datong

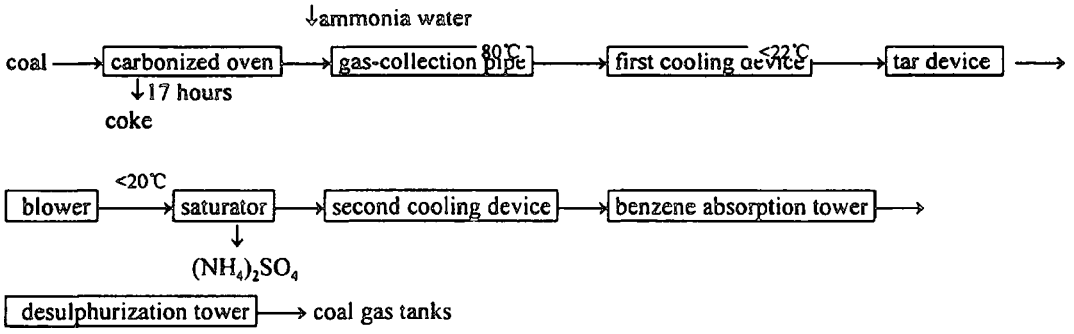
The gas resources in Datong are coal gas and liquid petroleum gas (LPG). As the result of development in the period of the "9th five-year plan", the total supply of pipeline gas of the whole city in 1999 is 77.73Mm^3, and that of LPG is 3906 ton. At the beginning of the "9th five-year plan", the number of gas-supply population was 600,000, and by the end of the "9th five-year plan" , the number has increased to 750,000. And at the same time, the rate of gasification has gone up from 70.9% to 79.8%.

3.3.1 Production of coal gas factories

The artificial coal gas of Datong is mainly from: the Coal Gas Factory of Datong Coal Gas Company, the Coal Gas Factory of Datong Mining Bureau and Yungang Coking Factory.

The Coal Gas Factory of Datong Coal Gas Company is located in the south of the city (No.1 Kaiyuan Street). There is all open ground around the factory, which can make a further development. The factory was build in 1985, and went into operation in 1988. The designing

capacity of daily coal gas production is 35.7×10^4 m^3 (among this, the gas production for nonlocal is 24×10^4 m^3, and that for the factory itself is 12×10^4 m^3), and the designing capacity of annual coke production is 23.3×10^4 ton. And now, the actual capacity can come up to the designing capacity. The main equipment involves 4 carbonized ovens (JCH-D) with 20 gates, and the daily coal-processing capacity of every gate is 12 ton. The total coal consumption of a year is 0.3Mt. There is a production flow chart.



Production Flow Chart

Yungang Coking Factory was established in the period of "9th five-year plan", and merged into the pipeline netting of Datong Coal Gas Company in 1998. The daily gas production for nonlocal is 12×10^4 m^3, and its main equipment involves 2 carbonized ovens (JCH-D) with 20 gates.

The Coal Gas Factory of Datong Mining Bureau went into operation in Sep. 1989, with 40 gates of 82-inch carbonized ovens. The designing capacity of annual coke production is 6×10^4 ton, and the daily gas production is 13.5×10^4 m^3, which is mainly used in the Bureau itself.

Owing to the shortage of gas supplies, the second engineering construction was carried on in the period of the "9th five-year plan". 3 water gas generators of Φ2.4m were built for the gas adjustment of peak-hour in Datong Coal Gas Company in 1997, and the designing capacity of daily gas production is 21.6×10^4 m^3.

3.3.2 Quality of coal gas, output of by-product and their sales

• Quality of coal gas

The pipeline gas in Datong is mainly artificial coal gas. Owning to the different technology of gas production, the compositions of the gas from different gas generators are different. The composition of coal gas produced by Datong Coal Gas Company is shown in table 3-10.

Table 3-10 Composition of Coal Gas (%)

Items	CO_2	C_nH_m	O_2	CO	CH_4	H_2	N_2	H_2S mg/m^3	Calculated Calorific Value (kJ/Nm^3)
Content	6.4	0.8	1.4	17.4	15.6	42.4	16.0	29	13014.9(3700kcal/Nm^3)

Source of the data: Datong Coal Gas Factory.

The coal gas quality defers to the enterprise's standard Q/MR(J) of Datong Coal Gas Company, which is shown in table 3-11.

Table 3-11 Quality Standard of Coal Gas of Datong Coal Gas Company

Q/MQ(J) 03.002-89

name \ index \ grade		qualified	high-quality	remarks
Calorific Value	kJ	14651	16325	net calorific value
H_2S	mg/Nm³	≤20	≤20	
NH_3	mg/Nm³	≤50	≤30	
$(C_{10}H_8)$	mg/Nm³	≤50	≤40	in Winter
		≤100	≤80	in Summer
O_2	%	≤1.0	≤1.0	

Source of the data: Datong Coal Gas Factory.

- **Production of the major by-products**

The by-products produced in Datong Coal Gas Company mainly are: coke (the annual output is 20×10^4 ton), coal tar (its yield is 3.3% per ton coal), semifinished benezene (its yield is 0.4%) and $(NH_4)_2SO_4$ (its yield is 0.2%). The quality standards of by-products are shown in table 3-12, 3.13, 3.14 and 3.15.

Table 3-12 Quality Standard of Special Coke for Alloy Iron

Q/MQ(J) 03.001-89

	Chemical Properties %							Physical Properties	
grade	A_d	$S_{t,ad}$	V_{daf}	M_t	FC_{ad}	in ash		chemical activity 1100℃ α%	powder specific resistance (normal air temperature) Ωmm²/m
						Al_2O_3%	P_2O_5%		
special-grade	≤9	≤0.8	≤2	≤8	≥88	≤18	≤0.20	≥68	≥2000
first grade	≤10	≤1.0	≤3	≤8	≥85	≤20	≤0.25	≥65	≥2000
second grade	≤12	≤1.0	≤5	≤8	≥83	≤22	≤0.30	≥60	≥2000
third grade	≤15	≤1.0	≤5	≤8	≥80	≤22	≤0.30	≥60	≥2000

Source of the data: Datong Coal Gas Factory.

Table 3-13 Quality Standard of Tar (Referring to GB3701-83)

Q/MQ(J) 03.003-89

name \ index \ grade		second grade	first grade	remarks
density (20℃)	g/ml	1.13~1.22	1.15~1.21	
matters undissolved in methybenezene	(dry basis)%	≤10.0	3.5~7.0	
ash	%	≤0.13	≤0.13	
moisture	%	≤4.0	≤4.0	
phenol content	(dry basis)%		≥10	
size	E80		≤5.0	

Source of the data: Datong Coal Gas Factory.

Table 3-14 Quality Standard of $(NH_4)_2SO_4$ (Referring to GB535-83)

Q/MQ(J) 03.004-89

grade / index / name	third grade	second grade	first grade	remarks
outward appearance	white or light yellow crystal			
content (dry basis) %	≥20.6	≥20.3	≥21	
moisture %	≤2.0	≤1.0	≤0.5	
free acid (H_2SO_4) %	≤0.30	≤0.20	≤0.05	

Source of the data: Datong Coal Gas Factory.

Table 3-15 Quality standard of Semifinished Benzene (Referring to GB3059-82)

Q/MQ(J) 03.005-89

grade / index / name	qualified	remarks
outward appearance	light-yellow transparent	
density g/ml	0.871~0.9	
fraction(<180℃) %	≥93	weight percentage
moisture	no moisture by observation	

Source of the data: Datong Coal Gas Factory.

• Sales of coal gas and the major by-products

In 1998, the average production cost of gas in Datong Coal Gas Company was 0.9 yuan /Nm^3. And the selling prices of gas for different purpose are shown in table 3-16.

Table 3-16 Selling Prices of Gas

for purpose	civil use	institutions, schools and organizations	industries	catering and service trade
selling price (yuan/m^3)	0.5	0.6	0.7	0.8

Source of the data: the Committee of City Construction of Datong (1999).

The coke is mainly used as the reductant for alloy iron, and 40% of sales are inside the country. The coke is mainly sold to the alloy iron factories in the North China, the northwest and the northeast of China. The producer price of the coke is about 300 yuan, and its production cost is 270 yuan. There are many standards of the major products: 5-15 mm, 10-30 mm, 10-25 mm, 25-50 mm and so on. The powder-coke takes up about 35% of the coke production, and it mainly sells to the cement factory with the selling price being 60-70 yuan. So, the average price of the coke is about 170-180 yuan.

The tar is mainly used for carbon black, waterproof paint, water division layer in the high way and ceramic tile baking, and the present selling price is about 1100 yuan/ton.

• Quality requirements and consumption of material coal

The annual coal consumption in Datong Coal Gas Factory is 0.3Mt. And the quality requirements for the material coal is shown in table 3-17.

Table 3-17 Quality Standard of Material Coal

Q/MQ(J) 02.001-89

grade / index / name	second grade	first grade
size percentage(13—80mm) %	≥75	≥80
moisture (Mt)%	≤8	≤6
volatile matter (V_{daf})%	27-34	27-34
fixed carbon (FC_{ad})%	57-65	57-65
ash (A_d)%	≤8	≤6
sulfur content (total sulfur)%	≤1.30	≤1.0
calorific value $Q_{gr,ad}$ (MJ/kg)	≥26.5	≥27.3

Source of the data: Datong Coal Gas Factory.

The daily raw material consumption in Datong Coal Gas Factory is shown in table 3-18.

Table 3-18 Consumption of Raw Material

coal consumption in carbonized oven	781.3 ton
coal gas	108.288 m^3
water	6000 ton
electric energy	51131 kWh
steam	824 ton
soft water	1250 ton

Source of the data: Datong Coal Gas Factory.

3.3.3 Situation of liquid petroleum gas (LPG) in Datong

There are 5 LPG companies in Datong: Datong LPG company, Guangji (广济) LPG supplying center, LPG station of Datong Road Bureau, LPG station of House Property Office in Datong Mining Bureau and Yuanxing (云兴) Warefare LPG Factory. And there are more than 50 supplying stations in the whole city. The designing volume of storage is 750 m^3. 40,000 families use LPG, and the annual supply of LPG is 3906 ton.

Recently, there is a certain development in pipe-supplying LPG, that is, the pure liquid petroleum is concentrated to be gasificated, and supplied to the consumers by pipelines. It is a complement in the areas where have not pipeline gas. And at present, there are 5000 families using the pipeline LPG.

3.3.4 Construction of town gas pipelines

There are 268km-long main pipelines of low pressure (116 km in the city and 152 km in Kouquan District, 口泉), and 400 km-long branch pipelines. And there are 99 pressure-adjusting stations (64 in the city and 35 in Kouquan) and 839 water-condensing vats (439 in the city and 400 in Kouquan).

The designing pressure system in conveying and distributing system of coal gas involves medium-pressure system and low-pressure system. The designing pressure of medium-pressure system is 0.13 MPa (1.3kgf/cm^2), and the actual pressure is 0.10 MPa(1.0kgf/cm^2). Because of the lower gas calorific value, the actual pressure of low-pressure system is adjusted, and the pressure into kitchen increases to about 1000-1200Pa (100mmH_2O~120mmH_2O) to ensure a good work of the gas.

The gas pipeline netting of Datong was established in the end of 1980s. The diameter of main pipelines of medium-pressure in the city is DN500-DN150, and that of low-pressure is DN400-DN200. The materials for pipelines are cast iron pipes. The sealing washer is made from nitrile-butadiene rubber, which will be aging slowly in the process of operation. And the pipelines in the courtyard are almost steel pipes. Most of the main pipelines of low-pressure in Kouquan District are seamless steel pipes, and parts of them are cast iron pipes (about 30km). And the pipelines in the courtyard are almost steel pipes. The anticorrosive ways of pipelines base on the national standard. The casing technique is used in the pipe joints. The specification of the gas meter is 2.5 l/h, which is produced by Dandong(丹东)Coal Gas Meter Factory and Chongqing(重庆)Liming Coal Gas Meter Factory.

There are 5 gas tanks in Datong, and the storage is 31.6×10^4m^3. There are 3 wet spiral tanks (the storage of each is 5.4×10^4m^3) and 4 coal gas compressors (exhaust volume of each is 120m^3/min) in Datong Coal Gas Company. In Datong Mining Bureau, there are 1 dry gas tank (10×10^4m^3), 1 wet gas tank (5.4×10^4m^3), 7 coal gas compressor (60m^3/min), and 3 coal gas compressors (120 m^3/min).

There are two measures for adjusting the gas supply of peak-hour in Datong. One is using water gas as the reserve resources to adjust the usage of gas in holidays. The other is using gas tanks to adjust the uneven use of gas, that is, storing gas in the low of gas usage and conveying gas in the peak of gas usage. Now, the daily gas supply is 22.5×10^4 m^3, and the uneven coefficient of gas use in a month, a day and an hour is respectively 1.20, 1.15, 3.20. In the peak of usage, the gas supply is 4.14×10^4 m^3 per hour. The present gas storing and conveying equipment can basically meet the work demands of the conveying and distributing pipeline netting.

3.3.5 Consumption of coal gas

According to the investigation of gas consumers, the consumers of pipeline gas in Datong are mostly residents, also including some offices, schools, organizations and catering and service trade, and the proportion of public construction and industrial consumers is very small. The distribution of the gas consumer is much non-balanced; especially there are only 2 industrial consumers at present.

By the end of 1999, there are 220,000 families using gas, in which 180,000 families use the pipeline coal gas (among these, 120,000 families in the city and 60,000 families in Kouquan). The pipeline coal gas volume of family consumption is 64.49Mm^3. There are 436 public construction

units using pipeline coal gas (including the offices, schools, hotels and so on), and among these, 391 units are in the city, while 45 units are in Kouquan District. The total sales of pipeline gas is 5.8Mm^3, and that in the urban and Kouquan is respectively 1Mm^3 and 4.8Mm^3. Two major industrial consumers of pipeline coal gas are located in Kouquan District, and the annual consumption of pipeline coal gas is 90×10^4 m^3.

Table 3-19 Distribution of Major Consumers of Pipeline Gas in Datong

distribution	residents	public constructions	industries
number	180,000 families	436	2
total	6449×10^4m^3	580×10^4m^3	90×10^4m^3

At present, the pipeline coal gas in Datong is mainly used for residential living where the burning equipment is gas stove. It is also used for heating boilers in some offices and hotel where the burning equipment is common heating boilers, and the major consumers are Commodity Inspection and Testing Bureau and Yinhe（银河）hotel.

3.3.6 Present problem and development plan

• Present problem

At present, there are some problems in the development of coal gas in Datong. (1) The distribution of gas consumers is not harmonious. The proportion of public constructions and industrial consumers is so small that the raw coal and bulk coal are burned in stoves for hot water and boilers, which causes low thermal efficiency, bad environmental sanitation and serious air pollution. Additionally, the uneven in the consumers' distribution is unfavorable to balance the usage of the city gas and the management of the gas usage in holidays, which may raise the gas reserve volume and investment of capital construction. (2) The 2 coal gas factories in Datong were respectively built in 1988 and 1989. Now the problems of equipment aging and gas-leakage are much serious, and it is time to repair the "first period gas furnace". There are also some problems in the "second period gas furnace". At first, the calorific value of gas is lower, and the average value is 10.87 MJ/Nm^3 (2600kcal/Nm^3), which can't meet the demand of national gas quality standard. The low calorific value leads to insufficient conveying and distributing capacity of pipeline netting and bad burning situation, which may influence the gas quality and raise the electricity consumption and the cost of conveying and distributing. Then, the content of CO is higher, and the average value is over 30%. In view of the present management of artificial coal gas, there is the shrinkage in the coke market and the blocked sales, and the gas price can't get any appropriate adjustment for many reasons, so that the production cost is higher than the selling price, and the loss of gas factories is serious. The total loss of coal gas system of Datong in 1998 is about 30 million-yuan. (3) Because the coal gas factory has run for 10 years, there is a certain aging in the pipeline netting of conveying and distributing gas. In view of the gas storage equipment, the present volume of gas storage can meet the demand of gas supply, but the distribution of the gas tanks in the city is not balanced. 3 tanks (5.4×10^4 m^3) are all located in the

coal gas factory, and connected by a main pipe of medium-pressure with the annular pipeline netting of medium-pressure where there is intensive load of gas supply. And this causes that the tanks can't be made full use.

• Development plan

In order to improve the air quality of the city and raise the people living standard, Datong has put forward the final objective that the coal would no longer be used for burning in Datong — the capital of the coal.

In the period of the "10th five–year plan", the gas supply resources are mainly artificial gas, nature gas will be introduced. In view of the actual situation of investigation, in the early stage of the "10th five–year plan", there is no conditions of introducing the nature gas to Datong, and the gas resources which can be utilized are still artificial gas and LPG. Since the artificial gas production and supply can be ensured, it should be made full use. It is estimated that artificial coal gas production and supply will not be changed in the early stage of the "10th five–year plan", and the daily supply volume of artificial gas will still maintain 37.5×10^4 m^3. In the late stage of the "10th five–year plan", after the nature gas is introduced to the city, the artificial gas will be partly replaced by the nature gas. By the time, the daily supply volume of the artificial gas will decrease to 21.77×10^4 m^3, and that of the nature gas will be 9.24×10^4 m^3.

Since the LPG has such properties as small investment, instant effect, convenient market management and its flexibility, it plays a major roll in the present gas development in Datong. Before the nature gas is introduced to Datong, the LPG will be quickly developed in some residential quarters. In the aspect of gas supply patterns, besides bottled supply, it should be encouraged to develop the pipeline supply of LPG in some areas where the economic conditions permits. Especially, in the period of the "10th five-year plan", the mixing centers of LPG and air should be built in a planned way in the city, which is an early preparation for introducing the nature gas. It is estimated that the LPG will be quickly developed in the period of the "10th five-year plan", and by the end of the "10th five-year plan", the daily supply volume of LPG will be about $23\times10^4m^3$.

According to the economic development of the city, the construction of the public building and the residential dwelling, it is planned that, by the end of the "10th five-year plan", the rate of gas popularity is 2.6% more than that in the beginning of the "10th five-year plan", which comes up to over 82.6%, and the population of gas usage increases from 70,000 to 820,000.

3.4 Situation of nature gas and development plan

At present, the nature gas resources have not introduced to Datong, and there are not the appropriate pipelines of conveying and distributing the nature gas. However, in order to improve the air quality, reduce the pollution, raise the living standard of the people, the department concerned has worked out a development objective of introducing the nature gas to replace the coal gas finally. Moreover, comprehensive development plans have been worked out for many

aspects such as gas consumers, gas resources and the system of conveying and distributing gas.

3.4.1 Work plans of introducing the nature gas in the period of the "10th five-year plan"

Since Shanxi province is rich in coal resources, and the price of coal is much low, a considerable quantity of coal will be still used, provided under the environmental conditions permit. Therefore, a part of coal will be still used in many industries before 2010, such as the large power plants for centralized environment control, most boiler rooms of centralized heat supply and the chemical plants that use coal as materials. Moreover, it won't be completely achieved to replace coal with gas in some industries and enterprises. And the reformation should be mainly carried out in some middle-sized and small-sized factories that cause serious pollution.

According to the construction rate of nature gas conveying from Shaanxi (陕西), Gansu (甘肃), Ningxia (宁夏) to Beijing and the relevant policies and financial sources of Datong, it is preliminarily planned to prepare for introducing nature gas in the early 2 years of the "10th five-year plan", start introducing nature gas in the late 3 years, and strive to finish laying pipelines for conveying nature gas and has the initial gas supply ability by the end of 2004.

According to the estimation, the annual introduction volume of nature gas in 2010 will be about 161.23Mm^3, and that in 2015 will be about 251.85Mm^3. If the above-mentioned objective of introducing nature gas can be achieved, the concentration of SO_2 in the air can be reduced under the standard-II.

3.4.2 Gas development plan of Datong from 2006 to 2015

• Development plan of gas consumers

According to the characteristics of consumers, the gas consumers involve the residential consumers, public construction consumers and industrial consumers. In view of the investigation of present gas consumers, Datong has worked out the development policy of increasing the ratio of public construction and industrial consumers step by step, with stress on the residential consumers. Moreover, since the nature gas will be used as fuel for automobiles, the nature gas as automobile's fuel will take up a certain ratio.

It is planed to make the nature gas as the main gas resource after 2005, which is based on introducing gas to Datong, and replace the artificial coal gas with the nature gas basically by 2015. It is estimated that the gas popularity of the city resident will be 87.5% in 2015, in which the popularity of pipeline gas will be 78%. The estimation of gas consumption of resident is shown in table 3-20.

Table 3-20 Estimation of Gas Consumption of Resident in Datong

year	numbers of families planned ($\times10^4$)	gas popularity (%)	families of gas consumption ($\times10^4$)			volume of gas consumption ($\times10^4$ m^3)					
			artificial coal gas	nature gas	LPG	artificial coal gas		nature gas		LPG (ton)	
						daily	annual	daily	annual	daily	annual
2000	21.5	80	17.5	—	4.0	21.0	7665	—	—	12	4380
2005	27.5	82.6	14.5	7	6.0	19.0	6935	5	1825	18	6570
2010	32	84.5	8.0	20	4.0	15	5475	19.8	7227	12	4380
2015	37	87.5	—	35	2.0	—	—	25.5	9307.5	6	2190

There are just a few gas consumers of public constructions in Datong, whose gas consumption is also in small volume. The main reason is that, since Datong is the base of coal production, and the price of coal is much low, most public construction consumers are not willing to replace the present coal with the gas considering the economic factors. In order to adapt the city to the mordernization development and increase the standard of environmental protection, there must be the variety in fuel struction of public construction, and the increase in gas consumption of public construction and the replacement of coal with gas. According to the present situation of public constructions and the forward development plan, the plan is worked out for future gas consumption, based on the present gas consumption of public constructions. And the estimation of gas consumption of public constructions is shown in Table 3-21.

Table 3-21 Estimation to the Gas Consumers of Public Constructions in Datong

year	number of families of gas consumption ($\times 10^4$)	volume of gas consumption ($\times 10^4$ m^3)					
		artificial coal gas		nature gas		LPG (ton)	
		daily	annual	daily	annual	daily	annual
2000	0.05	1.75	639	—	—	5	1825
2005	0.10	2.5	912.5	1.5	547.5	5	1825
2010	0.25	—	—	5	1825	3	1095
2015	0.35	—	—	10	3650	2	730

The present industrial consumers take up a much small ratio. According to the policies of gas development and the principles of gas supply, the ratio of industrial consumers should be increased step by step in order to promote the development of the city industries and raise the science and technology content of the city industries.

The importation of nature gas to the city will provide favourable conditions to the industries that use the gas as fuels, so the ratio of industrial consumers in the programme of gas supply should be increased step by step. By 2015, the artificial coal gas will be replaced basically by the nature gas, and the volume of gas consumption of industrial consumers will take up 34% the total volume of gas consumption of the whole city. The estimation of gas consumption of industries is shown in table 3-22.

Table 3-22 Estimation of Gas Consumption of Industries in Datong

year	daily volume of gas consumption ($\times 10^4$ m^3)		annual volume of gas consumption ($\times 10^4$ m^3)	
	artificial coal gas	nature gas	artificial coal gas	nature gas
2000	0.27	—	100	—
2005	0.27	2.74	100	1000
2010	—	11.88	—	4336
2015	—	23.5	—	8578

In order to reduce the environmental pollution caused by the tail gas of automobiles, the plans of the gas consumption of automobiles are as follows: After the nature gas is introduced to

the city, it will be used as fuel in the buses, individual managed automobiles and taxies. And by 2010, there will be 1500 automobiles changed to use the nature gas as fuel, and 8 nature gas stations will be built for the automobiles. The daily supply of nature gas for automobiles is 7.5×10^4 m^3, and the annual supply is 27.38M m^3.

According to the programme of gas consumption of different consumers, the gas consumption in every stage between 2000 and 2015 is shown in table 3-23 and table 3-24.

Table 3-23 Planned Gas Consumption in Datong (Daily Volume of Gas Consumption)

year	resident			public constructions			industries		automobiles	total		
	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)
2000	21.0	—	12	1.75	—	5.0	0.27	—	—	23.02	—	17
2005	19	5.0	18	2.5	1.5	5.0	0.27	2.74	—	21.77	9.24	23
2010	5	19.8	12	—	5.0	3.0	—	11.88	7.5	5	44.20	15
2015	—	25.5	6	—	10	2	—	23.5	10	—	69.00	8

Table 3-24 Planned Gas Consumption in Datong (Annual Volume of Gas Consumption)

year	resident			public constructions			industries		automobiles	total		
	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)	artificial coal gas ($\times10^4m^3$)	nature gas ($\times10^4m^3$)	LPG (ton)
2000	7665	—	4380	639	—	1825	100	—	—	8404	—	6205
2005	6935	1825	6570	912.5	547.5	1825	100	1000	—	7947.5	3372	8395
2010	5475	7227	4380	—	1825	1095	—	4336	2738	1825	16126	5475
2015	—	9307.5	2190	—	3650	730	—	8578	3650	—	25185	2920

• Development plan in gas resources

According to the investigation of the present situation of gas resources and the analysis of the present problems, it is shown that the gas fasilities of Datong City has fallen behind the pace of the gas development of the whole country, which is not coordinated to the policies of energy, city construction and environmental protection. So, new gas resources should be found to replace the present artificial coal gas.

According to the investigation, it is favourable to use the introduced nature gas as the gas resources. In accordance with the program of petroleum and nature gas enterprises in our country, it is estimated that by 2010, the annual gas supply capacity of the gas fields in Shaanxi, Gansu, Ningxia will come up to 10 billion m^3. Now the gas pipelines have been built from Shaanxi to Beijing, by way of Baode (保德),Shenchi (神池),Ying County (应县),Lingqiu (灵丘) which are in the northwest of Shanxi. The gas pipelines are very close to Datong (about 80 km). The diameter of the main gas pipelines is D660, and the maximum annual gas supply is 2 billion m^3, which has the ability and possibility of supplying gas to Datong. In addition, according to the energy programme of our country, it is planned to import nature gas from Russia to our country by

Mongolia, then convey the gas to Beijing, Shandong（山东）by Inner Mongolia（内蒙古）, Hebei（河北）. If the above-mentioned plan is carried out, the gas pipelines which is close to Datong will be connected with the main gas pipelines from the gas fields of Shaanxi, Gansu, Ningxia in the future, which will provide the dependable guarantee to the nature gas resources of Datong.

It is planned to draw a gas pipeline of high-pressure from the main gas pipeline of ShaanJing（陕京）(which is from Shaanxi to Beijing) then into the urban of Datong, and the total length of the gas pipelines is about 80 km. The gas received station and gas tank of high-pressure will be built in the south suburban of Datong, which are be used as the gas resources for the gas consumption of the city.

It is planned that the total length of gas pipelines with high-pressure from the main pipelines to Datong is 80 km, and the designing pressure in the starting point is 2.5MPa while that in the gas received station is 1.6MPa. The diameter of the pipe is D325. The insulating anticorrosion is strengthened and the cathode station is also set up to protect the pipelines.

According to the estimation of the nature gas consumption in Datong, the daily gas consumption in 2010 will be 44.2×10^4 m^3. And the maximum daily gas supply of the planned gas pipelines of high-pressure is 80×10^4 m^3, which can meet the need of a long-term development of gas consumption in Datong. Beside this, the rest can be used in other towns, which will refrain from repeat construction.

It is planned that the gas pipelines will be completed in 2004 and possess the ability of gas supply by the time. In 2005, they will begin to supply the nature gas to the city formally, and meet the needs of gas consumption programme of the city.

After the nature gas is introduced to the city, the present resources of the artificial coal gas will be replaced by the nature gas step by step. It is planned that by 2015, the popularization of the nature gas will be accomplished basically in the city, and the LPG now available will be the complementary gas resource for the city. The original artificial coal gas produced by the coking factory, whose daily production is 28.27×10^4 m^3, can be consumed inside the coking factory itself, which needs to reform from the boilers to the burning gas boilers, and construct its own power plant based on gas turbine.

• Development plan of gas conveying and distributing system

①Pressure system of the gas conveying and distributing system and the selection of materials for pipeline netting

It is planned that the nature gas will be introduced since 2005, and by the time the gas system now available for conveying the artificial coal gas will become the one for conveying the nature gas. Since the planned volume of gas supply will be increased greatly, it is necessary to adjust and reform the conveying and distributing system and the pressure system also needs appropriate adjustment.

There are two patterns of pipeline gas supply to the consumers. One is gas supply by low

pressure. That is, the gas of medium-pressure is regulated to that of low-pressure by a regional pressure-regulation station, then the gas of low-pressure is conveyed to the different consumers by a district pipeline netting of low pressure. The other is gas supply by medium pressure. That is, the regional pressure-regulation station is cancelled, and the gas of medium-pressure is conveyed directly to the consumers' gas regulators by the district pipeline netting. At present, the artificial coal gas is mainly conveyed by low pressure in Datong, and it is planned to adopt the pattern of gas supply by medium pressure in newly built quarters that are supplied with the nature gas. For the large amount of district pipeline netting of low-pressure that has been built at present, they can generally meet the need of the gas consumption of different consumers after the nature gas is imported to the city.

The pressure system of pipeline netting of medium-pressure: The regions of gas supply in Datong include the urban area, mining area and Wenying（文瀛）District, among these, Wenying District is the planned economic developing district. The conveying and distributing pipeline netting is completely different in the above-mentioned regions: most of the pipeline netting in the main urban area and mining area are cast iron pipes, which can bear only low pressure. And there are basically newly-planned pipeline netting in the economic developing district. So it is mainly based on economical and practical consideration that the pressure system of pipeline netting of medium-pressure is determined. In the period of programming (2010), the pressure system of medium-pressure pipeline netting of the city nature gas is determined as 0.1MPa.

②The selection of the material for pipeline netting

At present, the materials of pipeline netting of the artificial coal gas in Datong are cast iron pipes, which possess the properties of low cost and corrosion-resisting, so they are suitable for the characteristics of gas now available in Datong. However, the sealing property of the cast iron pipes is inferior to that of the steel pipes, and the ability of pressure-resisting of the cast iron pipes is quite poor, and these shortcomings cause the poor ability of operation of the pipeline netting. After the gas consumption increases, the steel pipes are used, which is advantageous to the long-range reformation of the pipeline netting and the increase of the pressure. So, in future, the steel pipes will be generally used in the medium-pressure pipeline netting of the artificial coal gas which are being built or will be built, and the original cast iron pipes under midium-pressure will be maintained.

③The gas conveying and distributing system

The plan of newly-building and reformation of the gas conveying and distributing system will be carried on in two periods: 2001-2005, and 2006-2015.

The main projects of conveying and distributing system from 2001 to 2005 are as follows: The gas received stations will be newly built for introducing the nature gas, and the daily gas supply is 80×10^4 m^3. A high-pressure sphere of 5000 m^3 will be built, whose designing storage is 1.6 MPa, and the position for building another same sphere is reserved. After the nature gas is conveyed to the received stations by the high-pressure gas pipeline that are connected with the

main pipelines of ShaanJing（陕京）, The pressure decreases to 1.6 MPa. Then after the purification, one route gets into the medium-pressure pipeline netting (0.1 MPa) of the urban after pressure-regulation and calculation, and the other gets into the high-pressure sphere of the nature gas (1.6 MPa). At the peak of gas consumption, the nature gas in the sphere will get in the medium-pressure pipeline netting of the urban after the gas-regulation and calculation.

In order to cooperate with the development of the consumers, the gas-regulation stations will be newly built or reformed. The reformation of the gas-regulation stations can take use of the original equipment such as civil constructions, and just reforms the pressure-regulators and the appropriate auxiliary equipment. And the box pressure-regulators can be set up if necessary.

Additionally, there will be newly built a dry gas tanks of low pressure ($5\times10^4m^3$) and the appropriate equipment of conveying, which will be set up in diagonal direction to the spheres in the gas received station.

④The program of conveying and distributing system from 2006 to 2015

By 2015, the popularization of the nature gas will have been accomplished in Datong, and the daily gas supply will come up to $69\times10^4m^3$. By the time, the gas pipeline netting in Kouquan, the urban and Wenying will be inter-connected, and the nature gas supply will be completely accomplished. Since the residents of each mine in Datong Mining Bureau will further concentrate in Kouquan District, the gas pipelines will be newly built or improved in Kouquan. And a part of old pipeline netting which was early built in the urban and Kouquan District will be also changed and reformed.

In the aspect of gas-storing equipment, the wet gas tanks of low-pressure will be no longer used in 2015, and a the dry gas tank of $10\times10^4m^3$ volume in the mining area and a dry gas tank of $5\times10^4m^3$ volume in the northeast of the city will be reserved in a diagonal direction. There will also be a high-pressure gas sphere ($5\times10^4m^3$) in the station. So the total gas storage in Datong is $20\times10^4m^3$, which can completely meet the needs of short-term and peak-hour adjustment of gas supply, and the coefficient of the gas storage is 0.40.

3.4.3 Conveying gasification-products of the hydrogasification factory

According to the programme of the enterprises of petroleum and nature gas in China, the gas pipelines of ShaanJing（陕京）have been built now, by way of Baode, Shenchi, Ying County, Ling qiu which are all in the northwest of Shanxi province, and the pipelines are only 80 km away from Datong. Datong has made a plan to introduce the nature gas from 2005. A branch gas pipeline of high-pressure will be designed to draw from the main gas pipelines of ShaanJing into the urban of Datong, and the total length of the branch pipelines is 80 km. A gas received station and high-pressure gas spheres will be also built in the south of the city. All these provide the effective guarantee for storing and conveying the gasification-products of the hydrogasification factory. In addition, the reason why we select Datong Coal Gas Company as one of places for building the hydrogasification factory is that Datong is the key area of introducing nature gas engineering construction, and the pipeline netting system and gas-storing equipment now available can be

convenient for the future hydrogasification. The gas products of hydrogasification can be conveyed into the main gas pipelines from this area, which can supply the gas not only to Datong, but also to Beijing, Tianjin through the main gas pipelines of ShaanJing.

3.5 Situation of coal chemical industry

At present, the coking factories with a certain scale in Datong are as follows: Datong Coal Gas Company: the annual coke production is 20×10^4ton; there are many kinds of standards of products, such as 5~15 mm, 10~30 mm, 10~25 mm, 25~50 mm; 40% products are sold to the alloy iron factories in the northwest and north of China, and the selling price is about 300 yuan per ton; while 60% products are sold to more than 20 countries in the Europe, Asia and America, and average FOB is 58 US dollar. Yungong Coking Factory: the annual coke production is about 10×10^4ton, which is mainly sold to the alloy iron factories inside the country, and the selling price is about 300 yuan. In addition, the potential industrial products involve: the construction project of 1Mt of CWS in Datong Coke Company, the project of 10Mt of coal preparationg, the project of graphite electrode of super strong power in Datong Carbon Factory, and so on.

3.6 By-products' utilization of hydrogasification factory

The by-products of hydrogasification are mainly BTX, that is, benzene and aromatic compounds. It is not much possible for these products to be used in the locality of Datong, so they can be transported to Beijing or Baotou（包头）to manufacture the products of high extra-value.

3.7 Conclusion

Through the comprehensive investigation above-mentioned of the basic facilities, the development of the coal gas and the future nature gas in Datong, we think it is greatly favorable to select Datong of Shanxi province as the place for the construction of the coal hydrogasification engineering.

Firstly, this project is supported and assisted energetically by the government and departments concerned of Datong, who provides a large amount of detailed and accurate materials and data.

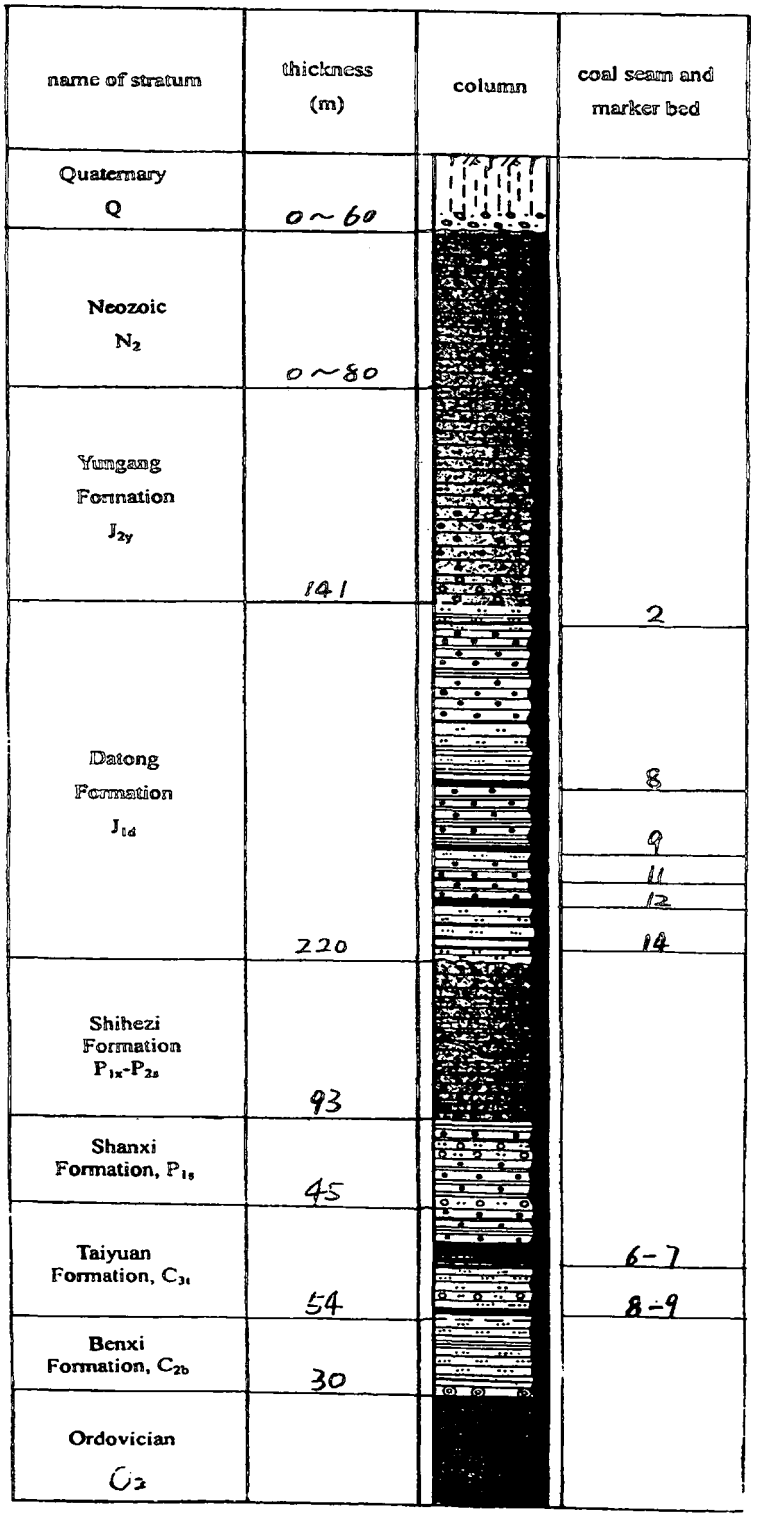
Secondly, as the largest city of coal production, Datong is very rich in coal resources, and it can provide the raw material of coal for hydrogasification for a long time, which can assure the supply of the raw materials.

Thirdly, according to the programme of the nature gas introduction in the periods of the "10th five-year plan" and 2006-2015, Datong is planned to invest in the reformation of the original equipment and build many basic equipment for the nature gas introduction, including the high-pressure gas pipeline (80km) connected with the main gas pipelines of ShaanJing, the dry gas tanks and high-pressures gas spheres (whose total gas storage is $20\times10^4m^3$), the medium-pressure main pipe (31.92km) and low-pressure main pipe (55km). All these measures provide dependable guarantee for the consumption and conveying of the gas products of the hydrogasification engineering.

So, it is exactly feasible to select Datong of Shanxi province as the place for the construction of the coal hydrogasification engineering.

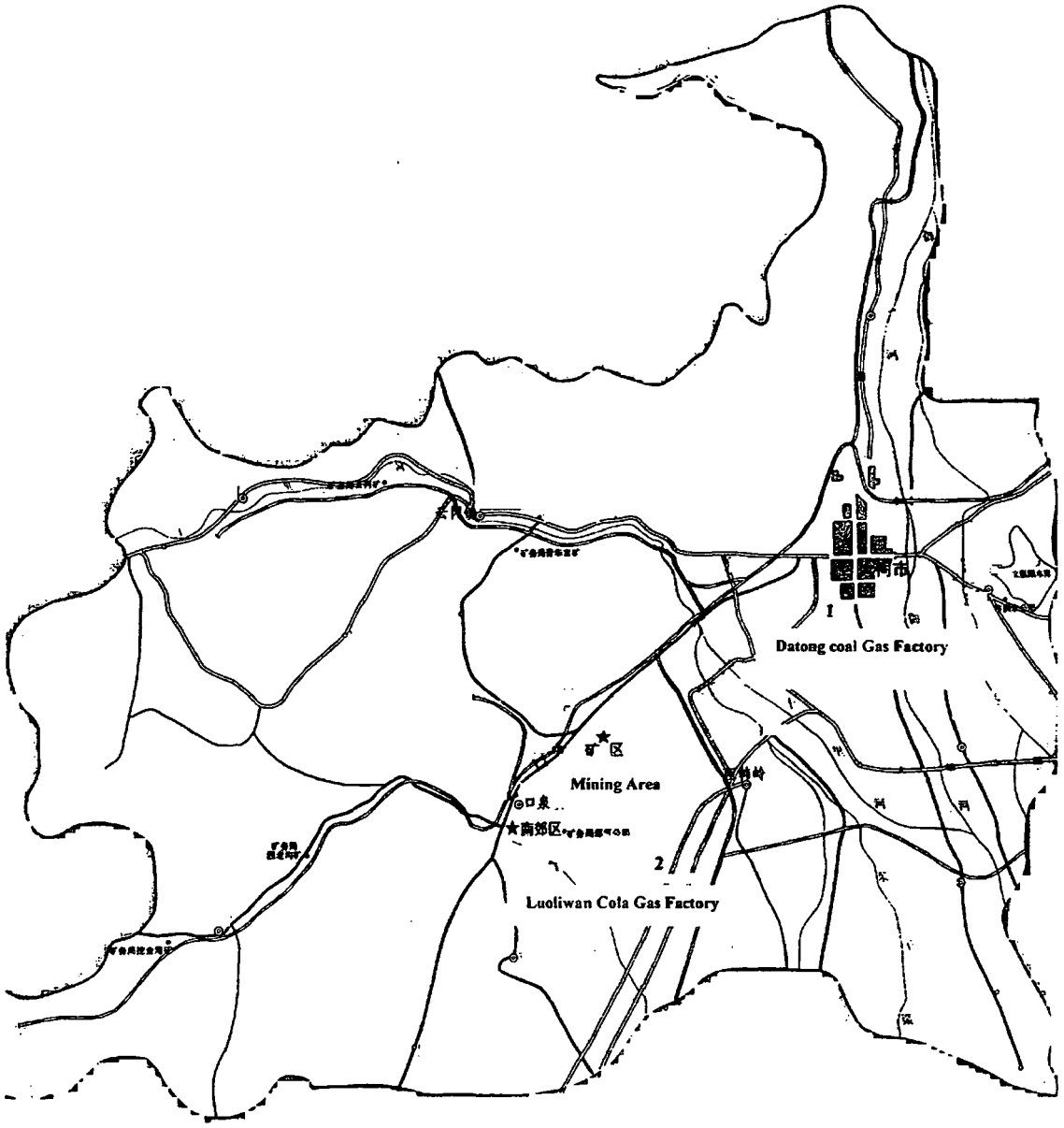
Attached Figure

Comprehensive Columnar Chart of Coal-bearing Stratum (Datong Mining Area)



Attached Figure

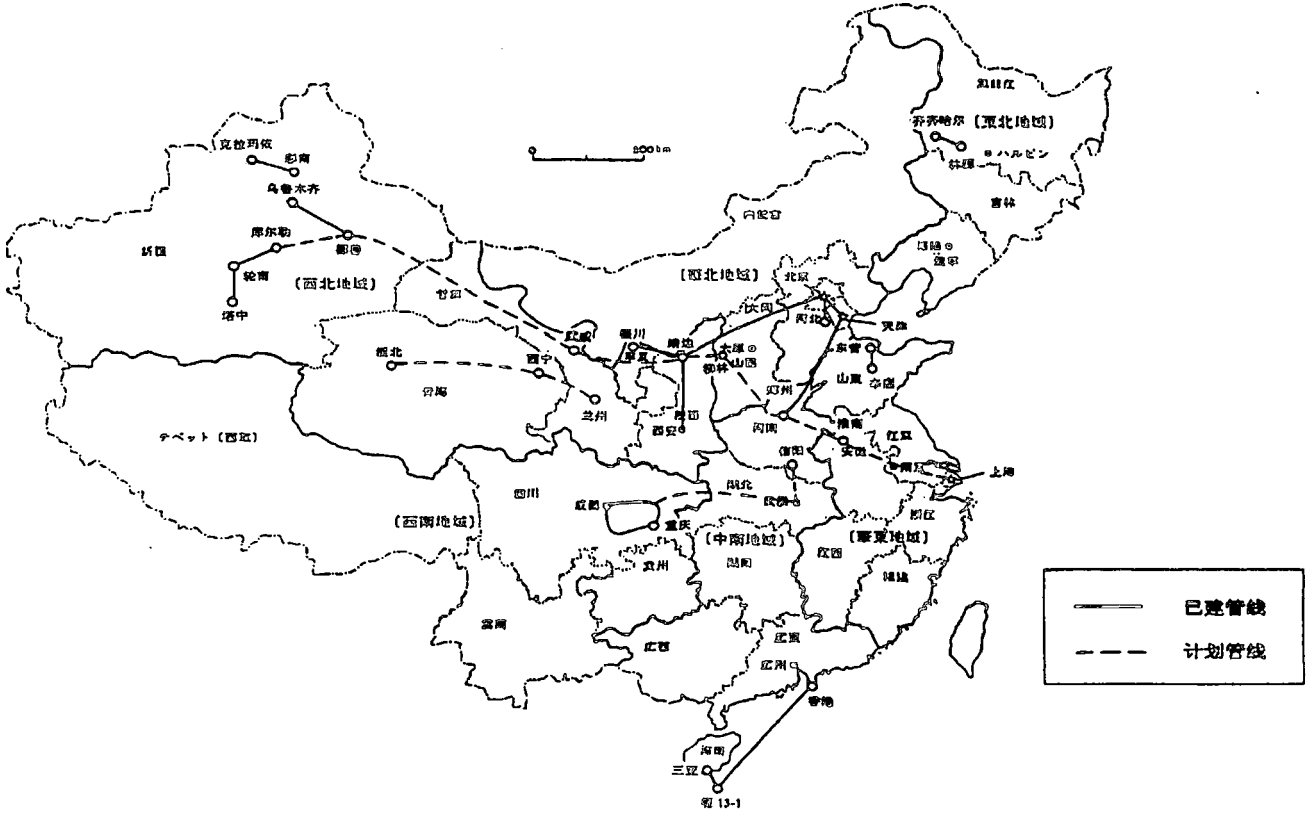
Candidate Site for Hydrogasification Factory —— Datong



note: 1 and 2 in the map are the sites selected for the hydrogasification factory

Attached Figure

Distribution of Nature Gas Pipelines in China



4 Suggestions on the feasibility of coal hydrogasification technology in China

4.1 Suggestions from BRICC

According to the investigation on the feasibility of the coal hydrogasification technology in China and the on-the-spot investigation in Urumchi of Xinjiang Autonomous Region and Datong of Shanxi Province, it is exactly suitable to the two cities above-mentioned as the bases for coal hydrogasification in terms of the situation of coal resources, the pipeline conveying and distributing system of the town gas, and the basic facilities of the city. The investigation lays a fine foundation for the development of coal hydrogasification technology in China and the further cooperation of Chinese and Japanese sides. The suggestions made by BRICC are as following.

① More exchanges are expected on the hydrogasification technology between China and Japan. BRICC has cooperated with NEDO on coal liquefaction for many years. According to the way of former cooperation, the experimental equipment is provided by Japan and is set up in BRICC. The experimental site and other facilities are provided by BRICC. The test and research on coal hydrogasification will be completed jointly by both sides.

② In order to accomplish the commercialization of hydrogasification technology as soon as possible, BRICC hopes Japanese side do the larger scale tests with the selected coal samples of Xinjiang and Datong, and send the results and data to BRICC.

③ It is expected that the Japanese side will continue to apply for the support of 通产省 after the bench-scale test is finished, and conduct further larger scale tests so as to accomplish the commercialization of hydrogasification technology. Chinese side will introduce advanced hydrogasification technology from Japan as soon as possible.

4.2 Suggestions from Xinjiang

The administrative personnel concerned of the Planning Committee of Xinjiang Autonomous Region and the personnel concerned of Coal Bureau, Gas Company, Mining Bureau and Research Institute of Coal of Xinjiang discussed on the feasibility of coal hydrogasification technology in Urumchi of Xinjiang Autonomous Region. Some of them accompanied the Japanese delegation to the on-the-spot investigation. They were all interested in this project, and many active suggestions are proposed.

① Urumchi hope to be the site for coal hydrogasification factory.

② The testing instruments made by Japan is expected to be set up in Xinjiang for testing. A part of funds may be invested by the government of Autonomous Region, and the government expects to continue the technical research and engineering development of hydrogasification technology with the coal in Xinjiang so as to accomplish the commercialization of coal hydrogasification as soon as possible.

③ At present, Xinjiang is programming the sustainable development strategy of energy.

Major goal is to develop new energy and clean energy. The programme, as the Sino-Japanese cooperative project, has been supported in finances by 通产省. The work plan has been made now. Thus, the project of coal hydrogasification can be incorporated in the programme, which may get the support from 通产省.

4.3 Suggestions from Datong

The administrative personnel concerned of Datong government and the personnel concerned of Datong Planning Committee, Datong Construction Committee, Gas Company and Mining Bureau discussed on the feasibility of coal hydrogasification technology in Datong. They were all interested in this project, and made many active suggestions.

① Coal industry is the main pillar-industry in Datong. Income from coal industry accounts for 60 percent of total income of the whole city, so the processing and conversion of coal is the main direction of the economic development in Datong. The short-term development strategy of Datong is based on the coal processing; medium-term development strategy, on the coal gasification. The coal hydrogasification technology accords with the energy development in Datong. Datong government and departments concerned pay great attention to it, and hope that the site for hydrogasification factory is selected in Datong in terms of the situation of gas resources, coal resources and gas pipeline construction. The Japanese side is expected to make a further research and discussion on the two candidate sites for hydrogasification factory.

② In the period of 1999-2000, under the support of the National Planning Committee and Planning Committee of Shanxi Province, the general programme of "Sino-Japanese sustainable Development of Energy—Shanxi Province" was made by NEDO, in which the main cooperation with Japan is in the processing and conversion of coal. Therefore, Datong thought that the project of coal hydrogasification can be incorporated in the sustainable development programme of the Datong's energy.

③ The departments concerned of Datong are planning to incorporate the project of coal hydrogasification in the development programme of coal processing and conversion. If the data of tests are available, it will be suggested to arrange the project in the development programme of the "10th Five-Year Plan".

5 Research and technical cooperation of the coal gasification technology in China

5.1 Introduction to BRICC

5.1.1 General introduction

Beijing Research Institute of Coal Chemistry (BRICC) of China Coal Research Institute (CCRI), founded in 1956, is the first research institute in China, which specializes in the coal chemistry and the technology of coal processing and utilization. The original researches of BRICC

were based on coal property research, analysis and test and preliminary processing and utilization technology. Through the development of 44 years, BRICC has become a specialized research institute of coal chemical engineering with various branches (involving coking, burning, special processing and so on) with stress on the research of gasification and liquefaction. Several technological units for enlarged tests of gasification, liquefaction, burning and coking have been installed in succession, of which some units and technologies are in an international advanced level. Especially in 1990s, BRICC is devoted to the division of the technology of coal chemical engineering, and meanwhile, carries on the research of the technological evaluation of the utilization of coal chemical engineering, and promote the commercialization of the achievement of science and technology. It also develops the international cooperation actively and pursuits the lately development of world clean coal technology.

At present, there are 9 research divisions in BRICC, that is, coal property research, analysis and testing center, coking, coal liquefaction, coal gasification, coal combustion, special processing, instruments developing and energy saving center. BRICC has 125 employees, of whom 9 are professors, 44 are senior engineers, and 32 are engineers. Granted by the State Council, BRICC is authorized to confer the doctorates and master's degree in several specialties. Presently, there are 6 doctoral tutors and 5 master tutors, and 6 doctors and 2 masters are studying in the institute. And BRICC has trained 5 doctors and 18 masters in past 10 years.

5.1.2 Introduction to research divisions of BRICC

• Coal property research

BRICC is always in the lead in the field of coal property research in China. Through many years of hard work, it has basically kept information on the coal resources and coal property in China, and worked out a national and regional systematic compilation of coal property materials, which is of great importance to promote the rational utilization of coal. There is variety of classes of coal in China, and BRICC has completed the research and formulation of the classification of Chinese coal under the support of departments concerned. In order to promote the rational utilization of Chinese coal, various industry standards of coal consumption, classification standards of coal quality and coal supply standards for mining area were drafted in accordance with the characteristics of coal resources in China and the status of coal processing and utilization technologies. The formulation and implementation of these standards promote further the rational utilization of Chinese coal.

Since 1980s, the computer technology has been firstly used in the research of coal property, and the first national "Database of Chinese coal Resources" was established, including 70,000 coal samples, 9,620,000 data and more than 800 data items. The database mainly involves: ①basic parameters of coal, such as recoverable deposit, thickness of coal seams, plunge and strata property on the roof and floor of different coal seams, different ranks, different classes and different ages in state-own key coal mines, local state-run coal mines and main sifting geographic exploration region; ② Systematic analysis data of coal property, technical properties parameters

of coking, gasification and coal burning, and experimental results of screening and flotation in mining area and sifting exploitation region; ③ distribution data of 31 associated elements in more than 1000 coal seams and testing data of coal maceral in more than 400 coal seams in the state-own key mines and local state-run coal mines. The database possesses great function of searching, drawing and technical and economic evaluation. Since it was established, it has provided a large amount of advisory service to various departments, such as metallurgical industry, power industry, architectural materials and chemical industry. It has produced good social and economic benefits. Moreover, many new researches are developed with the aid of the computer technology, such as "prediction of coal quality in mining area", "coal quality expert system" and "optimization scheme for steam coal blending". The prediction of coal quality in Kailuan(开滦) mining area and the schemes for steam coal blending in Hangzhou (杭州) of Zhejiang (浙江) Province, 3 provinces of the northeast China, Zhuzhou (株洲) Coal Washery, Huainan (淮南) Mining Bureau and Steam Coal Blending Centre of Qinhuangdao (秦皇岛) have been completed in succession. A set of applied software of DOS 3.1 and Win 98 of optimization scheme of steam coal blending has been worked out to provide a whole set of technical service of steam coal blending.

• **Analysis and testing, quality control and standardization of coal**

The China National Center for Quality Supervision and Test of Coal was established in BRICC, which was granted by National Economic Committee in 1987. It passed the authentication of the National Commercial Supervision Laboratory and Authorization Committee of National Laboratory of China. Moreover, the center has become an authoritative testing organization in accordance with the International Standardization Organization (ISO) system.

The China National Center for Quality Supervision and Test of Coal is engaged in the analysis of coal. At present, it has 30 professional researchers, 70 percent of whom are professors, senior engineers and engineers, and has more than 150 instruments. Over 50 analytical experiments of coal (coke) properties can be performed in the center, which is one of the biggest coal laboratories at home and abroad.

The center, as the authoritative organization of standardization of testing methods for Chinese coal, has formulated 49 national standards, 19 industry standards, and 29 standard materials which belongs to 9 groups. The methods and standards for coal analysis formulated by the center are more than those of ISO and other main advanced industrial countries except the former Soviet Union; and they all reach the ISO level in the aspect of technology, 10 of which possess the creativity and are in the lead of the world. The center began to develop the special instruments for coal tests in 1970s. In past 30 years, more than 40 special instruments for coal tests are developed and put into production. 12 patents are achieved, which are in the lead of the world.

As the technical member of the Solid Fuel Committee of ISO (ISO/TC27), the center participates the activities of ISO actively. At present, 5 persons are the specialist member of the working group concerned of ISO/TC27, one of them is the chief leader, two of them are in change

of projects. They have drafted 6 international standards for ISO. The center can also conduct the analytical tests according to the Chinese standards (GB), international standards (ISO), American standards (ASTM), Australian standards (AS), Germany standards (DIM), Russian standards (GOST) and Japanese standards (JIS).

• **Research of mixing coal for coking and pyrolytic technology of coal**

The Coking Division of BRICC is specialized in the research of coal coking and the pyrolytic processing of young coals, and provides quality supervision and test and the engineering technical service of coal and coke products. It has made a greater contribution to the research and determination of the technical scheme of mixing coal for coking in tens of coking plants with large-, medium- and small- scale in the country, such as the Coking Plant of Baoshan (宝山) Iron and Steel Company, Taiyuan (太原) Coal Gasification Company.

The Coking Division is equipped with the testing coking-oven of 5 kg, 40kg and 200kg, small-scale coal washing machine, stamped machine for coking, small coal briquetting machine and continuously coke briquetting equipment, screening units of coke and a whole set of analytical instruments of coke quality. Tests of routine coking, stamped coking, coking with mixing-coal and coal briquetting, and coke briquetting with fine anthracite can be conducted. Moreover it is engaged in analysis of coal and coke quality indexes, and the development of premium foundry and metallurgical coke and coke for chemical industry and iron alloy section. In resent years, it is also in charge of the quality supervision and test of the export coke in China.

Since 1980s, the research on coking technology is aiming at the development of technology and products for the premium foundry coke, including the premium foundry coke production with fine anthratic and coals with high volatile matters, the improvement of pyrolytic technology of coal and the utilization of products.

In the process of research of mixing-coal for coking, the mixing-coal method using gas coal was presented, which broke through the mixing-coal method using coking coal. G-V graph of mixing-coal technology was proposed to guide the coal-mixing and predict the strength of coke, which broke through the conventional V-Y method so that the coal-mixing is more rational. The caking index (G) was created to evaluate the properties of coking coal and used in the classification of coal. Moreover, a series of achievements have been obtained in the technologies of stamping coking, preheated stamping coking, coking with mixing-coal and mixing-briquetting coal, briquetting coking, and so on. In the process of research of coke properties, the work is centered on the thermal properties of coke, and the changes regularity and the influencing factors in the thermal properties of coke are presented to guide the coal mixing. In the process of research of mixing-coal technology with coal petrology, the relationship of G-I is established, and the relationship among the structures, properties of coke maceral and the technical conditions of coking is deeply researched. In the process of technical development of premium foundry coke, the foundry coke of second grade, first grade, extra grade and high density are produced.

Owning to the combination of advancement and practicality of mixing coal for coking, the

production quality with favorable market competition and the good properties, the technology has made better economic benefits in tens of coking plants with different scales, and it has been awarded 3 national and ministry first-class and second-class prizes respectively in 1985, 1991 and 1995. The foundry coke of extra-grade produced by pilot-scale plant in Shanxi(山西) is all exported to the other countries, such as the USA, Japan and Thailand. Moreover, it is the "quality test-free" product in Tianjin(天津) Commercial Supervision Bureau.

The pyrolytic process of the young coal is a new technology developed by Coking Division in resent years, which is used in the continuous pyrolytic processing and clean utilization of low-class coals as brown coal, long flame coal, non-caking coal, weakly caking coal and gas coal. The laboratory is equipped with the pyrolytic units with different scales from 1 to 100 kg/h. The research and technical development can be carried on according to the different use of coal and coal properties to obtain the high added value products. Especially, the development of multi-use of pyrolytic semi-coke products has obtained achievements, such as: semi-coke used as the carbonaceous reductants for industries of premium iron alloy and calcium carbide (high specific resistance, high reactivity), and as the coal-based adsorbents in living sewage disposal and oil pollution disposal of rivers and lakes, which make remarkable power-saving effect and economic and social benefits.

• Research on coal-based activated carbon

The Special Processing Division of BRICC is mainly engaged in the technical researches on processing coal into various products with high added value through different processing technology. Before 1980s, many related researches had been carried on in BRICC, such as "the development of carbon granule of Chinese coal", "the development of OT10-50 carbon granule microphone and the manufacture of the premium carbon granule in China", "the extraction and production of wax in brown coal".

Since 1980s, the division was engaged in the research and development of carbonaceous materials, which is centered on the development of activated carbon products, the routine test of the products, the investigation on the feasibility of building a factory and the consultancy service of engineering technology. Since 1989, it began to contract for the engineering projects of activated carbon, the development of new activated carbon products, the establishment of activated carbon division in National Supervision and Test Center and interrelated trade of activated carbon. And since 1994, it began to emphasize particularly on the research and development of the products with high technology content.

At present, the division possesses the bench-scale equipment of pulverizing, briquetting, activating and carbonizing of activated carbon, the whole set of standard supervision and test instruments of activated carbon of the USA, Japan and China, 1800 specific surface-area determinator of Italy, electrode plate of activated carbon, and so on.

Through the ten years of hard work, the division possesses the advanced technology of coal-based activated carbon in the country. It is the first one to succeed in the development of many

new kinds of activate carbon in China, such as: activated carbon for desulfurization, activated carbon for sewage disposal, activated carbon for recovery of solvent, activated carbon with low ash, activated carbon for controlling evaporation of automobile fuel and briquetting activated carbon, in which the research of activated carbon for silver carrier and coal-based activated carbon has applied for the national patents. Moreover, the division has completed more than 10 provincial and ministry projects, designed more than 10 activated carbon factories, and achieved Grade A license for technical consultation and Grade B license for engineering design on activated carbon.

The analysis and test of activated carbon has been checked and accepted by the government and incorporated in the National Center for Quality Supervision and Test of Coal. In 1997, it passed the authentication of the National Commercial Supervision Laboratory and Authorization Committee of National Laboratory of China, and it is an authorized organization in accordance with the standard of ISO.

• Research of coal liquefaction

The technology development of direct coal liquefaction began in 1980, which was centered on the direct coal hydroliquefaction and the processing and utilization of the coal derived liquid. The final goal of the research is to develop the technique of Chinese coal liquefaction to provide whole set of technical design for building the coal liquefaction factory in China.

BRICC has set up one 0.1ton/day pilot continuous coal liquefaction unit provided by Japan, one 1.8kg/h unit with kettle-type and tube-type reactors exported from the USA, one 0.12t/d unit provided by Germany, and introduced a large-scale modern analytical instrument with the total value of US$500,000 funded by United UNDP. Up to now, in the process of the research of coal liquefaction, 15 areas of coal production have been selected as the bases of coal liquefaction in China, and technique tests for 4 coals have been completed. The maximum oil yield can reach 55%, and qualified gasoline, diesel oil and aviation gasoline can be made from coal-derived oil. By use of the achievements, the process design of manufacturing gasoline and diesel oil from the tar hydrogasifiction (65 kt/a) has been completed.

The research of direct coal liquefaction has been highly emphasized by the government. The State President Jiang Zemin (江泽民) and Vice Premier Wu Bangguo (吴邦国) inspected the CCRI on January 19, 1996. They visited the direct coal liquefaction laboratory specially. At present, the feasibility researches for setting up the direct coal liquefaction demonstration factory in Yilan(伊兰) and Harbin(哈尔滨) of Heilongjiang(黑龙江) Province have been completed successfully in cooperation with JICA, NEDO and CCUJ of Japan. The National Development and Planning Committee of China has approved that the project will be carried on in the future.

• Research on coal burning and briquetting

In order to solve the series of problems caused by the direct burning of coal, a systematic research has been made on fluidized bed combustion and coal briquetting. Achievements have been obtained. BRICC helped Beijing Mining Bureau to set up the 2t/h and 6t/h fluidized bed boilers using inferior anthratic and refuse as the fuels. And the projects are completed in

succession, such as: "the development of new type 130 t/h fluidized bed boiler", "the improvement of 35 t/h fluidized bed boiler". In 1996, the project of "The research on 35t/h fluidized bed boiler using high-water, high-ash and high-slime water as fuel" was completed, reaching the advanced level in the world. Moreover, these projects solved a series of problems on the preparation, transportation, feeding and burning of slime water.

In recent years, there has been great achievement in the research and development of the coal briquetting technology, and many technologies with their own characteristics are formed, such as briquette blender, production process and equipment in coal briquetting. Especially in these years, there has been great breakthrough in the briquette technology, and industrial briquette and households briquette with perfect waterproof and non-drying are developed successfully. Many kinds of coals can be selected for the manufacture of briquette, such as bituminous coal, anthratic and slime water. Briquette can be used as fuel for fixed bed gasification boilers, industrial boilers and kilns. HS compound-blender and the gasification briquette with perfect waterproof represent the lately research level on the coal briquetting technology in BRICC. And briquette formula and briquette production technology can be provided according to the different coal properties and the different demands of products.

HS industrial briquette with waterproof can save the conventional processes of carbonization and drying, which can simplify the process greatly and reduce the investment of building a factory by a big margin, and the products are suitable for the long-distance transportation. In addition, the industrial briquette can decrease ash content compared with the carbonized briquette, reduce smoke and dust emission, increase in the efficiency of sulfur capture and combustion efficiency compared with the fine coal, decrease fuels cost and production cost compared with the lump coal, and has the remarkable economic and social benefits.

5.1.3 Coal gasification in BRICC

BRICC has been engaging in the research on the coal gasification since 1950s. Coal Gasification Division of BRICC is an authoritative professional division, which is specialized in the research of basic theory and new technology of coal gasification, high-and low-temperature coal gas clean up, related products development, and the evaluation of coal gasification properties. It has tens of senior engineers and engineers of R & D, and obtains many state patents on gasification technology. The division has completed many state and ministry key projects and projects funded by UNDP, including town gas engineering construction projects with gas clean up and energy saving for industry and civil use. Many achievements have awarded state and ministry scientific prizes.

- **Well-equipped laboratory**

The division has established world level laboratories, including the pilot-scale pressurized fixed bed gasification laboratory with dry ash exhauster, bench-scale pressurized fixed bed gasification laboratory and bench-scale pressurized fluidized bed gasification laboratory, catalytic gasification laboratory, direct methanation pressurized gasification laboratory with sulfur-

resistance, and pressurized gasification indexes determination laboratory.

The division possessed tens of modernized analysis instruments, which can carry out quantitative analysis of almost 50 items on coal gas, tar, phenol water, coal and ash. The pilot-scale pressurized fixed bed gasification laboratory with dry ash exhauster is mainly equipped with a pressurized fixed bed gasification boiler (Φ650mm) with dry ash exhauster, and many units such as coal stock, medium-pressure boiler, liquid-oxygen station, air pump station, coal gas clean up, water treatment, waste water containing phenol furnace and control room. In addition, the laboratory can take on the evaluation of gasification properties in different processes. The data can be used in feasibility research of gasification plant construction. The division also researches the relationship of between the pilot-scale gasifier and the industrial gasifier so as to design coal gasification plant.

BRICC jointly developed and established two Φ100mm bench-scale pressurized gasifiers (one with fluidized bed and another with fixed bed) with the Foster Wheeler Company of the USA, were put into operation in 1986. The features of the gasifiers system are high operating pressure, high automation, continuous feeding and ash-removal, feeding level indication, automatic weighing indication of feeding and ash-removal, on-line gas chromatography, safe interlock, automatic recording and drawing with 32 parameters, and so on. They are in the international advanced level of 1980s.

At present, the division also possesses the analysis instruments of sewage water and tar, the determinator of dust content in coal gas and small-scale test instruments for pressurized-gasification with fixed bed and fluidized bed, which are equipped with the on-line gas chromatographic analyzer and the on-line sulfur detector. The evaluation tests of the gasification properties on tens of coals have been finished. In addition, the division set up the evaluation laboratory of high-and low-temperature desulfurization sorbents for coal gas. SMOVEN desulfurization process of high-temperature flue gas with world advanced level has been developed successfully.

• **Basic theory research on coal gasification and achievements**

In past decades, BRICC conducted large numbers of researches on the basic theory of gasification and the gasification engineering development. In the basic theory research, it was emphasized on the new type catalyst that applies to react with water gas, the catalytic gasification dynamics of the typical Chinese coals and the gasification indexes with gasification properties.

In bench-scale fixed bed reactor, type II catalyst (combined by two compounds), E, F, G types catalyst and type III catalyst (combined by three compounds) have been developed under atmospheric pressure and 700~800℃. These catalysts were used in the tests of steam catalytic gasification with different coals, such as: Jingxi (京西) anthratic, Yangquan (阳泉) anthratic, Jinhuageng (晋华宫) medium-volatile bituminous coal, Xinglongzhuang (兴隆庄) high-volatile bituminous coal, Shenbei (沈北) brown coal, 5 kinds of low-volatile, high-volatile and strongly caking bituminous coals and sub-bituminous coals of the USA, 2 kinds of brown coals of the USA

and Germany, and so on. Carbon conversion ratio in gasification process increases by 5.5~30 times because of these catalysts. At the same time, these catalysts raise the reaction rate, decrease the operation temperature. All of these improve the mathematic model of methanation and the hypothesis of reaction mechanism, conforming the macrodynamics to the micromechanics.

The quality indexs of coal gasification involve mechanical strength, thermal stability, clinkering property, chemical activity, ash fusibility, and ash viscosity. Through a large number of tests, the national standards on the determination of the reaction activity, clinkering property, and ash viscosity of coal have been formulated under atmospheric pressure; and the national standards on the determination of thermal stability, mechanical strength and ash fusibility have also been formulated. All of the standards are used in the whole country. At the same time, the reaction activity of pressurized gasification has been researched, and achievements have been obtained.

In the aspect of the processes development, since 1960s, gasification with fixed bed and fluidized bed under atmospheric pressure, gasification using brown coal, high-temperature entrained bed gasification and fine coal gasification in molten slag pool have been developed, reaching the pilot scale or industrialized test level. In 1970s, the division developed various briquettes for gasification using humic acids as blender, which were used in the chemical fertilizer factories in Beijing (北京), Guangdong (广东) and many places. A Φ650mm pressurized gasifier with dry ash-removal was established in 1983. Pressurized gasification tests using Yilan (伊兰) coal, Shenbei (沈北) coal, Huangxian(黄县) coal, and other coals were conducted in the Φ650mm pressurized gasifier. The test results of Yilan (伊兰) coal and Yaojie (窑街) coal were respectively used in the feasibility research and design of coal gas stations in Harbin (哈尔滨) and Lanzhou (兰州). Since 1980s, the research focused on the new type catalyst that reacts with water gas and the catalytic gasification dynamics. In the late of 1980s, Φ1.6m two-stage water-gas gasifier suitable for the residents in the coal mining area was developed, which was popularized in Inner Mongolia(内蒙古), Shanxi(山西) Province, Shandong (山东) Province and so on, and 8 coal gas stations were set up and put into operation. The achievements above-mentioned have won the second-grade prize of scientific and technical progress of former Coal Ministry.

Φ100mm bench-scale pressurized gasifiers (one with fixed bed and one with fluidized bed) developed by China and the USA were advanced in its design and reached international advanced level of 1980s. In the period of the "7th five-year plan", gasification process condition test under atmospheric pressure and pressurized and coal properties research (such as reactivity, clinkering property and pyrolysis property) were carried out. More than 40 kinds of Chinese coals were tested in the gasifiers, and the database of coal gasification properties was established.

In the early of 1990s, the division undertook the state key project of "8th five-year plan" — "the research of key technologies on IGCC", and set up Φ300mm pressurized circulating fluidized bed gasification unit in the Research Institute of Electricity Generation Facilities in Minhang(闵行) District of Shanghai(上海). The tests of 5 coal samples were carried on successfully, and the

achievement awarded the prize of state key project in the "8th five-year plan". The division also undertook the project funded by UNDP entitled "Hot gas clean-up and desulfurization in China". Pressurized bench-scale batch-run fluidized bed reactor, bench-scale continuos-run fluidized bed reactor, dust remover of coal gas were set up. In addition, the division developed two-stage gasifier once more, including two-stage MKZ-J gasifier, the computer optimizing design of the two-stage gasifier, new type structure of distillation stage and so on. Moreover, methanation process for two-stage water-gas gasifiers and pilot-scale test for catalysts were completed. And the successful development of this technology will promote the development of town gas, increase the efficiency of coal gasification, save the coal and reduce the pollution.

In the aspect of the engineering design of coal gasification, the division is mainly engaged in the design of medium- and small-scale gasifiers, the gasification process design, the pipeline network design for gas transport. Φ2m gasifiers, coal gas stations with Φ3m gasifiers, Φ2m two-stage gasifiers have been designed and completed by the division in Yinchuan(银川) of Ningxia (宁夏) Province, Dawukou(大武口) of Ningxia, Hunan(湖南) Province, Linanyuangang(连云港), Beijing(北京) and so on. And the division also participated in the feasibility research, construction and operation of Qinhuangdao（秦皇岛） Coal Gas Factory. W-CT gasifier- "replacing coke with coal" developed by the division has been popularized in Beijing, Tianjin (天津), Handan(邯郸) and so on, with a better benefits. Moreover, the Φ2m two-stage gasifier won the third-grade prize of scientific and technical progress of former Coal Ministry, and it was used in the production line for wall brick introduced by Italian. The design of the coal gas stations adopted the new process of gas clean-up, reduced wastes emission, reached advanced level in China.

In the aspect of international cooperation and academic exchange, the division has established a good cooperation relationship with many countries such as the USA, Japan, Germany and Australia.

5.2 Research in Institute of Coal Chemistry of Chinese Academy of Sciences

5.2.1 General introduction

The Institute of Coal Chemistry, Chinese Academy of Sciences (ICC, CAS) was founded in 1954 at Dalian (大连), originally named as the Laboratory of Coal Research, Chinese Academy of Sciences. It was moved to Taiyuan (太原) in 1961, greatly expanded since then, and renamed the present name in 1963. In the period from 1966 to 1978, its name was once changed to the institute of Fuel Chemistry.

Through the development of 45 years, the ICC has become one of the most important coal research organizations in China. It mainly engages in fundamental, strategic and comprehensive high-technology research and development on the efficient and clean utilization of coal and keeps conducting important scientific and technological projects. The ICC also pays great attention to the applied research and development on new carbon materials and fine chemicals. The major research fields of ICC are coal chemical technology, catalysis, new carbon materials and chemical

engineering. The ICC consists of several research laboratories and research centers, which include State Key Laboratory of Coal Conversion, Development Division of Chemical Technology Research, Engineering Research Center of Coal Conversion, Research Division of New Carbon Materials, Laboratory of Coal Liquefaction, Laboratory of Coal Gasification, Designing Department and Engineering Consulting Center. All these have formed an integrated scientific research and development system from fundamental research, applied research to process development.

At present, the ICC has 621 staff, in which 393 are scientific research professionals, including 1 member of Academy, 40 professors, 96 associate professors and senior engineers, 174 assistant professors and engineers. The ICC also pays close attention to post-graduate student education. It is authorized to confer the doctoral and master degrees in a number of specialities. Currently, 77 doctoral students and 42 master students are studying in the Institute. In addition, a post-doctoral research center was set up to host post-doctoral researchers from other institutions.

In the past 45 years, the ICC has won particular attention and full support from the State, CAS as well as Shanxi (山西) Province. It has carried out a large number of key projects, major applied research and Science Foundation projects from national agencies, CAS and provincial governments. In accordance with the requirement of the national economy development, the ICC devotes itself to the research on coal classification, coking coal blending, coal pyrolysis, basic organic synthesis from coal and petroleum, coal liquefaction, coal gasification, new carbon materials, gas purification, supercritical extraction, coal-based activated carbon, coal briquet and humic acid fertilizers. It has been plying exclusive role in national economy development, resource exploration and rational utilization as well as developing new research fields. Over 300 important scientific achievements have been attained. More than 100 patents have been issued or under application. Over 3,500 papers have been published.

The ICC has been active in international cooperation. The long-term and extensive academic exchange and the mutual personnel visiting have been established with the United States, Russian, United Kingdom, Germany, Japan, Poland, etc. Collaborative research projects in many fields have been successfully carried out. International conferences related to the coal science, C1 chemistry, fluidization, etc. have been hold successfully.

Based on the principle of "Truth seeking, realistic approach, collaborative work and creative spirit", the ICC takes full advantages of multi-disciplines integrity, superior facilities and outstanding scientists, to carry out knowledge innovation program. It will endeavor to attain the leading position in the frontier of clean coal technology, to form powerful, strategic reserve of high-tech coal energy and other environment-friendly technologies, to actively commercialize the innovation and revolutionary technologies to become the real production. It will provide support to the development of high-tech industry of new carbon materials, promote commercialization of fine chemicals products. It is expected that the ICC will make even greater contribution to the sustainable economic development in China in the next century.

5.2.2 Introduction to various research groups

• State key Laboratory of Coal Conversion

The State Key Laboratory of Coal Conversion (SKLCC) was established in 1991 and was officially open in 1995. The SKLCC is aiming at being a high-ranking lab in the world, which is devoted to the fundamental and applied research on the coal conversion. Its research scope is the science and technology related to the coal conversion to fuels, chemicals and materials. It will comprehensively develop the coal chemistry, physical chemistry as well as engineering science. Emphasis is put on the key subjects and frontiers in these.

There are many advanced analytical instruments in the laboratory, such as: physical adsorption analyzer, transmission electron microscopy, gas chromatography-mass spectrometer, rapid heating thermo analyzer, and Fourier Infra-Red spectrometer.

Main research subjects: fundamentals of coal conversion; transformation of sulfur, nitrogen and other pollutants in coal conversion and effective removal techniques; theory and technique of catalytical control in the efficient utilization of hydrogen and carbon in coal; Engineering and process simulation of coal gasification and synthesis gas conversion; new materials for energy and environment application; Science and technology in catalyst preparation.

• Engineering Research Center of Coal Conversion

The aim of this Center is to develop and demonstrate efficient, clean coal technologies, and to realize knowledge innovation through technical innovation. A professional contingent devoted to the basic engineering research and development has been growing up in the past years.

There are demonstration facility of coal-based synthetic gasoline, pilot plant of coal-based synthetic gasoline and catalyst evaluation installation in the research center.

The Center consists of a coal gasification laboratory, a coal liquefaction laboratory, and a pilot plant base. It has conducted extensive research on coal gasification, indirect coal liquefaction, integrated coal gasification and combustion, gas clean-up, and integration and optimization of energy system. It has cooperation and links with a number of domestic and overseas research institutions and enterprises.

The pilot plant base occupies 108,000 m^2 of land. It has been equipped with a pilot ash agglomerating gasifier, a pilot plant of synthetic gasoline, a workshop of catalyst preparation, syngas producers and utilities. These facilities provide favorable conditions for scaling-up of the coal conversion technologies. They are open to the domestic and overseas partners as well.

Main fields of research and development: fluidized gasification and combustion of coal fines and the process development of proper gasification system for the utilities and chemical endusers; indirect coal liquefaction; synthesis of hydrocarbons; alcohols and ethers from syngas; removal and reuse of pollutants in the coal gas and flue gas; research and development of zeolite catalysts; scaling-up of catalyst preparation.

• Development Division of Chemical Technology Research

This Division is mainly devoted to transferring research achievements to practical use in the

field of fine chemicals and developments of new techniques. Young and middle-age professionals compose the core of the Division. Combining a number of well-experienced R & D groups with Designing Department, Engineering Consulting Center, etc., the Division will have advantages of good conditions in research, development and engineering of practical technology as a whole. It possesses quite a lot of achievements and technologies developed on its own in the fields of catalytical hydrogenation, supercritical CO2 extraction, methanol chemistry, heat-resistant polyurethane, gas purification, special gas production, coal-based activated carbon and coal briquetting. Considerable social benefit and economic benefit were attained with commercialized technologies. For example, the refinery gets 200 millions yuan RMB profit annually when hydrogenation of raffinate from reforming process is used. More than 100 institutions and enterprises of electronic and chemical industries use the ultra-pure gas and special gas production installations developed by the Institute.

The Engineering Consulting Center, engaged in the techno-economic assessment and environment evaluation, is the only A-level engineering consulting unit in CAS, approved by the State Commission of Development and Planning.

Main research and development areas are as follows: catalytical synthesis and hydrocarbons conversion under supercritical condition and preparation of fine chemicals; hydrogenation of raffinates from reforming process; Ultra-pure gas and special gas production; research on the alumina reinforced aluminum composites; synthesis of the heat-resistant polyurethane; down-stream products of methanol and dimethyl carbonate; highly efficient and clean coal briquet for combustion; the application of low temperature plasma for the treatment of waste water and waste gas and for the combustion promotion in the engine; techno-economic assessment and environment evaluation.

• Research Division of Carbon Materials

As the first laboratory of carbon materials in China, the Research Division of Carbon Materials was established in early 1960's. Now it becomes an important base of new carbon materials research. A contingent with multi-discipline background in science and engineering occupies a leading position in the fields of R & D of PAN, rayon and pitch based carbon materials and composites in China. It has been entrusted with a number of state key projects and has carried out international cooperation. The Division has the largest carbon fiber pilot plant and production line, initiated on its own, in China, and the most advanced continuous production technology of wide felt of activated carbon fiber. In this Division, dozens of new products has been developed, some important achievements were obtained, and over 400 papers were published. All these achievements, technologies and products have widely been applied to the sectors of chemical technology, energy, communication, national defense, aeronautics & aerospace, and sport apparatus. It led to some new high-tech industries in China.

Main research fields: characterization and preparation techniques of new carbon materials; high performance composites from carbon fiber and alumina fiber; carbon based electro-magnetic

functional materials; preparation and structure and performance study of high thermo-conductivity carbon; high temperature adhesives; impregnation and gradient impregnation of silicon on to carbon materials; R & D of special porous carbon materials.

Appendix 1 Determination of the candidate site — Datong in Shanxi

According to the original agreement, the candidate site for the hydrogasification project in Shanxi (山西) province is the region surrounding Taiyuan. According to the situation of coal resources and development of nature gas of Taiyuan (太原) and around Taiyuan, Datong (大同) City is finally fixed as the candidate site for the project.

1 Advantage of Datong in geographical position and transportation

Datong City is located in the place where three provinces (Hebei(河北) , Shanxi(山西) and Inner Mongolia (内蒙古)) meet. Datong City is a hub of important railway in the north of China, and highway also lead in all direction. Datong City is all relative short distance to Beijing, to Baotou(包头) and to Taiyuan(太原), so Datong City possesses favourable conditions in regional competition.

2 Advantages of Datong in coal resources

Datong is the largest city of coal production in China, and Datong coal is famous all over the world. Datong is in more urgent need clean coal technologies than that in any other cities in China, so they pay great attention to the project. In addition, Datong, as "the largest capital of coal", is very rich in coal resources, moreover, the quality of Datong coal is good and its price is low. Datong coal can be used as the better material for hydrogasification, and the supply of materials coal can be guaranteed.

3 Advantages of Datong in future nature gas supply

Though Datong dose not introduce nature gas from other city now, and there is not pipelines for conveying and distributing nature gas, the departments concerned in Datong has worked out the final objective of introducing nature gas to replace coal gas. The comprehensive development programme has been formulated, such as sources of nature gas, conveying and distributing system of nature gas, and so on. It is planned that, in the period of the "10th five-year plan" and 2006~2015, the existing equipment will be renovated, and infrastructures will be built, including the high-pressure gas pipeline of 80 km-long which is connected with gas pipeline of ShaanJing(陕京). The connection with the main gas pipeline, which is from west to east, will provide the dependable guarantee for conveying and the local consumption of the gas products of the future hydrogasification factory.

According to the above analysis, it is more rational to change Taiyuan to Datong as the site for hydrogasification in Shanxi.

Appendix 2 Report of on-the-Spot Investigation in Urumchi and Datong

According to the agreement, Japanese delegations have made two on-the spot investigations respectively on the 2nd-4th of June and the 23rd-29th of September in 2000 on the basic facilities, city gas pipelines and coal mines construction of Urumchi and Datong for the sake of the comprehensive understanding of the specific situation of the two cities selected as the sites for hydrogasification engineering in China.

Japanese delegates: 丸山英夫、宝田恭之、胜仓宏次郎、大滨隆司、近藤康彦、伊奈孝、津留义通、浅岗善清

Chinese delegates: Duminghua (杜铭华), Liwenhua(李文华)

Jiangying(姜英), Wangyu(王雨)

The delegation, accompanied by the personnel concerned of the Planning Committee of Xinjiang Autonomous Region, visited Liudaowan (六道湾) Coal Mine under Urumchi Mining Bureau for the sake of the understanding of the material coal supply for hydrogasification engineering, and a colloquium was held with the personnel concerned of the coal mine so as to understand the basic situations of the coal properties, the production and construction of the coal mine and so on. It also visited the Head Petrochemical Factory of Urumchi for the sake of the investigation on the nature gas pipelines of Urumchi, and a colloquium was held with the personnel concerned of the factory so as to understand the basic situation of production, construction and products of the factory. In addition, the delegation visited the Daban(达阪) Wind Power Plant of Urumchi for the sake of investigation of the basic municipal facilities of Urumchi.

The Sino-Japanese delegation arrived at Datong of Shanxi Province on the 28th of September in 2000. It visited Wuguantun(吴官屯) Coal Mine (the place of material coal supply), accompanied by the personnel concerned of Datong Planning Committee, and got a general understanding on the production, construction and coal quality of the coal mine. In order to get information of production and consumption of town gas in Datong, the delegation visited the Coal Gas Factory of Datong Coal Gas Company, which is selected as the site for hydrogasification engineering, and got an understanding on the production, quality and pipelines of coal gas. In addition, the delegation made an investigation on the specific situation of the Shaan-Jing(陕京) gas pipelines (which is in the vicinity of Datong) and the junction point where the main pipelines and the original pipelines meet in Datong for future transmission of hydrogasification products.

Through the on-the-spot investigations on the two cities selected as the sites for hydrogasification engineering, the specific situation of the municipal facilities, town gas, coal production, coal properties of the two cities above-mentioned is understood and grasped, which lays a fine foundation on the accomplishment of coal hydrogasification engineering in the future.

Appendix 3 Experimental Data of Coal Samples from Datong and Urumchi

Attached Table 3-1 Data of Proximate Analysis

	M_{ad} (%)	A_d (%)	V_{daf} (%)	CRC	FC_d (%)
Datong	7.25	14.66	31.07	2	58.83
Urumchi	3.36	9.26	36.33	3	57.77

Attached Table 3-2 Data of Ultimate Analysis (%)

	C_{daf}	H_{daf}	N_{daf}	$S_{daf}+O_{daf}$	C_d	H_d	N_d	S_d+O_d
Datong	82.50	4.65	0.83	12.02	70.40	3.97	0.71	10.26
Urumchi	83.36	5.41	0.90	10.33	75.64	4.90	0.82	9.38

Attached Table 3-3 Data of Calorific value (kJ/kg)

	$Q_{gr,ad}$	$Q_{gr,d}$	$Q_{gr,daf}$	$Q_{net,ad}$
Datong	25.52	27.51	32.24	24.59
Urumchi	29.35	30.37	33.47	28.30

Attached Table 3-4 Data of Ash Analysis (%)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	TiO_2	P_2O_5	Na_2O	K_2O	MnO_2
Datong	56.26	21.55	15.59	1.67	0.72	0.82	0.80	0.45	0.22	1.97	0.131
Urumchi	50.26	22.92	6.82	6.81	2.81	1.06	1.55	0.06	0.79	1.24	0.101

Attached Table 3-5 Data of Ash Fusibility (℃)

	DT	ST	HT	FT
Datong	1080	1290	1300	1310
Urumchi	1160	1260	1280	1310

Attached Table 3-6 Data of Harmful Element Analysis

	$S_{t,d}$ (%)	F (μg/g)	Cl (%)	P_d (%)	As (μg/g)	Pb (%)	Hg (μg/g)
Datong	1.79	94	0.027	0.0350	10	0.002	0.131
Urumchi	0.50	—	—	—	—	—	—

Appendix 4 Preliminary Test Results of Hydrogasification

Preface

Hydrogasification (or called hydro-pyrolysis) , as one of the novel developing gasification technologies, aims at the generation of Substitute Natural Gas(SNG) or/and liquid production such as BTX, through the further reaction between pyrolysis yields with hydrogen. In Japan and USA, lots of studies on this subject are carried out. In China, under the 'seventh-five-year plan' project sponsored by National Commission of Science and Technology', the relevant project were also undertaken including the methane generation mechanism, hydrogasification kinetics, hydro-pyrolysis and so on..

In term of arrangement of Japan-China cooperation project, the Datong coal and Xinjiang coal were preliminarily tested in the mode of hydrogasification. The test results are briefly introduced as following.

1 Coal Samples

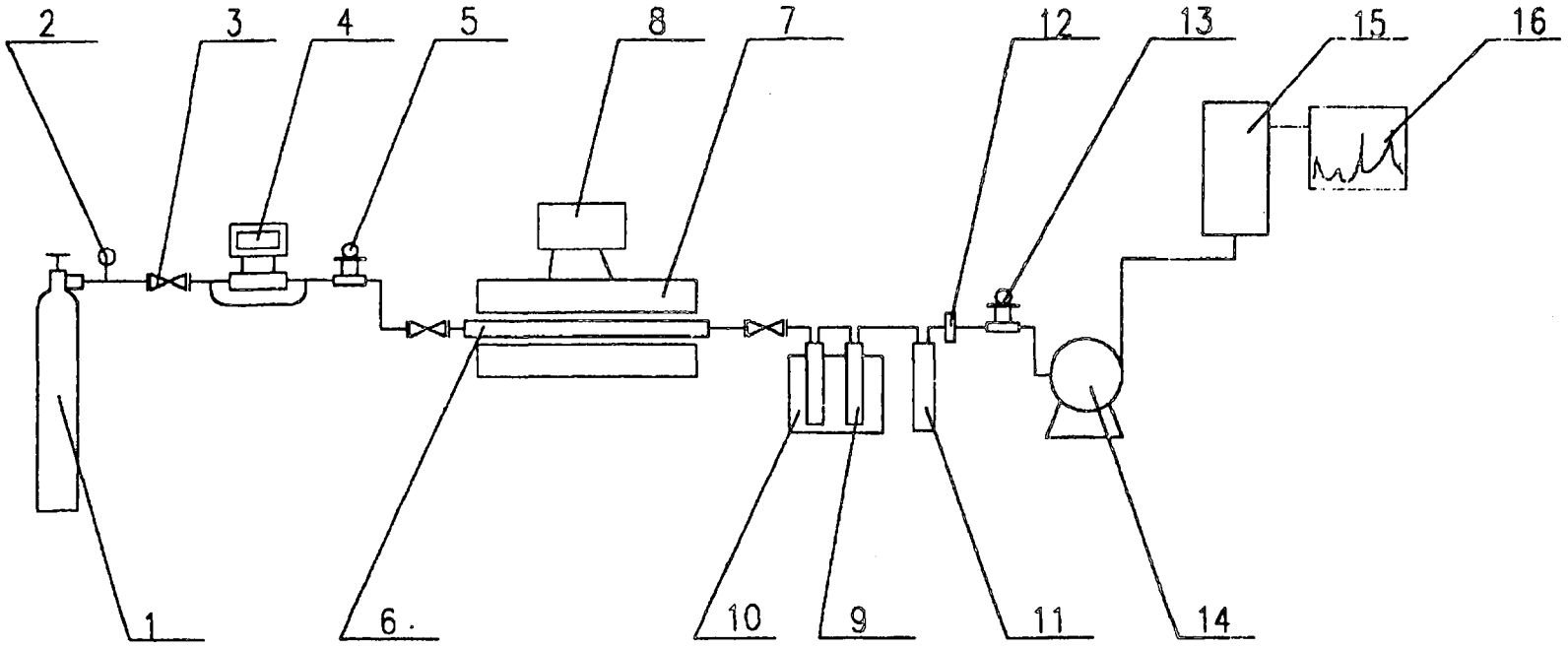
The project designats Datong and Xinjiang coal as test samples. The analysis results are given in attached table 1.

Attached table 1 Coal Analysis

Item	M_{ad} %	A_d %	V_{daf} %	CRC	FC_d %
Datong	7.25	14.66	31.07	2	58.83
Xinjiang	3.36	9.26	36.33	3	57.77
Item	C_{daf}	H_{daf}	N_{daf}	$S_{daf}+O_{daf}$	$Q_{gr,ad}$
Datong	82.50	4.65	0.83	12.02	25.52
Xinjiang	83.36	5.41	0.90	10.33	29.35

2 Experimental System

Attached Figure 1 shows the diagram of experimental system. The reactor, which is heated by electricity coils, is a horizontally placed stainless steel tube with inner diameter of 50 mm. The hydrogen from pressure bottle is firstly pressure-adjusted and then is measured by mass flow controller. After sample loading, the reactor temperature is quickly increased to the set point and the hydrogen flows through the sample bed, where the hydro-pyrolysis and hydrogasification are occurred. The production from reactor goes passing the condenser, in which the tar and water are cooled, separated and collected. The gas is then de-pressurized and vented to a gas bag for measuring the volume. The gas composition is analyzed in gas chromatograph. The liquid part is divided into oil phase and water phase by distilling.



1. Gas Bottle
2. Pressure Gange
3. Three-way Valve
4. Mass Flow Meter
5. Pressure adjustor
6. Reaction Tube
7. Electricity Heater
8. Temperature controller
9. Gad Cooler
10. Water Bath
11. H2S Adsorber
12. Gad Filter
13. Pressure adustor
14. Gas Meter
15. Gas Holder
16. Gas Chromatograph

Attached Figure 1 Pressurized Pyrolysis Test System Diagram

After each test, the material balance is made and to give the yield of gas, oil, water and char.

3 Test Results

Two coal samples are tested in hydrogen atmosphere and the test conditions are as following:

Sample Size: 0.5—1 mm

Sample Load: 60 gram

Reaction Temperature: 850 ℃

Reaction Time: 30 minute

Operation Pressure : 0.1-2.5Mpa

The test results are given in table 2. It is observed from the table that obvious difference between the two series of data for both coal samples even at the same test condition. Relatively, Datong Coal features higher oil yield and methane content in gas than Xinjiang Coal even though Xinjiang Coal has higher volatile content. The total conversion is higher for Xinjiang Coal than Datong Coal and this is consistent with the property of volatile because of coal pyrolysis is the main contribution to the conversion.

Attached table 2 Prelininary Test Results of Hdrogasification

Coal Sample	Datong	Xinjiang
Sample Load, g	60	60
Gasification Agent	H2	H2
Operating Pressure, MPa	2	2
Reaction Temperature, ℃	850	850
Gas Flow Rate, ml/min	500	500
Reaction Time, min	30	30
Gas Compositiopn, vol%		
CO	2.58	5.76
CH_4	23.10	18.78
C_2H_4	0.08	0.18
C_2H_6	0.68	0.62
C_3H_8	0.15	0.08
CO_2	2.02	3.14
Yield		
Oil Yield, %	5.68	2.88
Water Yield, %	6.33	13.22
Char Yield, %	67.70	59.95
Total Conversion, %	32.30	40.05

4 Conclusion

1) Datong Coal and Xinjiang Coal have been preliminary tested in a horizontally placed tube reactor for hydrogasification

2) Datong Coal gives higher oil yield, methane content and less conversion than Xinjiang Coal at the same condition

Appendix 5 Sustainable Development Strategy of Energy in China

At present, China is in the crucial moment of reconsidering the energy development strategy. So as to accomplish modernization, the strategy of Chinese energy development should be adjusted to optimize the energy mix, increase the efficiency of energy utilization, make the establishment of international multi-energy supply system as the strategic goal of a long-term energy supply, improve energy quality, exploit nature gas as the key point of the energy exploitation in next century, strengthen the construction of energy basic facilities such as the pipeline network system of nature gas, lay stress on the development of premium primary-power like nuclear-power, hydro-power and wind-power, and accelerate the development and utilization of clean coal technology. Therefore, China is formulating the medium- and long-term objective of energy sustainable development of the "10th five-year plan", "2015" and "2050". The strategic objective of the energy development can be simply described as: provide the continuous energy supply with the most economy, safety, high-efficiency and clean, and insure the accomplishment of the objective of social economic development — reach the people living standard of the medium-developed countries in the middle of next century in China. For accomplishing the objective, we should understand the status and development trend of the world energy industry. At the same time, we should also understand the status of Chinese energy industry and the demands of energy market, especially the important role of coal energy in the sustainable development strategy of Chinese energy in order to keep up with future development.

1 Status and development of world energy industry

1.1 Status of the world energy industry

• Status of energy consumption

According to "the medium- and long-term energy strategy in China" made by the Energy Institute of the Nation Planning Committee of China, the data is presented as following.

Total energy consumption: in 1996 total primary energy consumption in the world is 8380.1 Mtoe (12.99 Btce), an increase of 3.0% over the previous year; that of 1986 is 7110 Mtoe; during 1986 to1996, average annual energy consumption increased by 1.65%.

Energy consumption per capita: in 1994 the energy consumption per capita of the developed countries is 5.07 toe, China is only 0.664 toe, which is a great gap from the developed countries. For detail to see attached table 5-1.

• Energy consumption mix

In the total primary energy consumption of the world in 1996, the first is oil (3312.8Mtoe), and the second is coal, the third is nature gas, and the following is nuclear power and hydro power. The primary energy consumption mix is shown in attached table 5-2 and 5-3

Attached table 5-1 Energy Consumption per Capita in Some Countries

Unit: kgoe

Year	China	Japan	USA	France	UK	Italy	Korea	Canada	Germany
1980	421	2972	7908	3539	3572	2466	1087	7854	4587
1994	664	3856	7819	4042	3772	2707	2982	7854	4128

Sources of data: the data of China is from *Statistical yearbook of China*, and those of other countries are from *Development Report of the World (1997)* of the World Bank.

Attached table 5-2 Consumption and Mix of World Primary Energy in 1996

Unit: Mtoe

	Total	Oil	Nature gas	Coal	Nuclear	Hydro power
Consumption	8380.1	3312.8	1971.6	2257	621.3	218.1
Ratio (%)	100.00	39.53	23.53	26.93	7.41	2.60

Attached table 5-3 Primary Energy Consumption Mix of Some Countries in 1996

Unit: %

Country	Coal	Oil	Nature Gas	Primary-Power
China	74.6	18.0	1.8	5.5
USA	24.2	39.1	26.7	10.0
Canada	10.3	35.6	29.7	24.3
UK	19.5	36.4	33.3	10.8
Germany	25.8	39.8	21.8	12.6
France	6.0	37.4	11.9	44.7
Italy	7.5	60.1	29.9	2.6
Former USSR	19.6	21.3	51.3	7.8
Japan	17.6	53.8	11.9	16.8
Korea	19.2	61.6	7.4	11.8
Australia	44.1	36.7	17.7	1.4
Average of OECD	20.5	42.8	23	13.6
Total of World	26.9	39.5	23.5	10.0

Sources of data: the data of China is from *Statistical Yearbook of China*, and those of other countries are from *Statistical Yearbook of World Energy (1997)* of Britain Oil Company.

• Mix of energy consumption

In the mix of energy consumption in developed countries, the energy consumption is equally distributed in industry, traffic, and civil use / commerce / agriculture. Moreover, because of the higher production level in developed countries, industrial energy consumption is decreasing gradually; that of traffic and transportation is increasing; and that of commerce, agriculture and civil use is in a stable level in a long time, shown in attached table 5-4.

Attached table 5-4 Mix of Energy Consumption in Some Countries

Country	Industry		Traffic		Commerce, Agriculture and Civil Use	
	1980	1993	1980	1993	1980	1993
China	34.93	30.35	33.91	38.33	31.17	31.32
USA	38.16	37.27	29.61	28.57	32.24	34.16
Canada	33.58	25.85	25.37	32.65	41.04	41.50
UK	40.32	32.07	18.97	27.00	40.71	40.93
Germany	39.29	29.73	23.57	31.08	37.14	39.19
France	42.16	33.90	24.51	32.20	33.33	33.90
Italy	53.22	50.50	15.51	13.19	31.27	36.31
Former USSR	63.09	62.50	7.89	9.96	29.02	27.54
Japan	52.70	45.78	22.82	27.27	24.48	26.95
Korea	44.12	49.48	14.71	20.62	41.18	29.90
Australia	39.13	37.93	39.13	39.66	21.74	22.41
Average of OECD	38.15	33.13	28.85	33.53	42.99	33.33
Total of World	43.88	40.10	24.74	27.35	31.38	32.55

Sources of data: materials of Energy Data and Model Center of the Institute of Energy Economy of Japan (EDMC, IEEJ) from *Statistical Handbook of Energy Economy of Japan (1996)*.

• Efficiency of energy utilization

The energy consumption of every 10,000 US$ GDP in the country of OECD in 1994 is 29.7 Ktoe, which is 28.8% lower than the average level of the world. Annual energy saving of the world in the period of 1980~1994 is 0.30%, and that of the country of OECD is 1.06%.

Attached table 5-5 Comparison of Energy Utilization Efficiency Between China and Some Developed Countries (1987)

Unit: toe/GDP, 10^4 US$

	China	USA	Japan	France	UK	Italy	Korea	Canada	OECD	World
1980	33.33	4.76	1.82	2.44	3.57	2.08	5.56	5.88	3.45	4.35
1994	14.29	3.85	1.61	2.27	2.86	2.22	5.56	5.00	2.94	4.17
Rate of Energy Save* (%)	5.87	1.51	0.85	0.50	1.58	-0.46	0.00	1.15	1.13	0.30

* the average energy saving of 1980—1994.

Sources of data: *Development Report of the World (1997)*, the World Bank.

• Changes of energy consumption mix of the world

In past 50 years in the mix of primary energy consumption, the oil consumption increased about 345 Mtoe, accounting for 27.3% of total, with average annual increase of 1.1%. The nature gas consumption increased about 522 Mtoe, accounting for 41.3% of total, with average annual

increase of 3.1%. The coal consumption increased 1.57 Mtoe, accounting for 12.4% of total, with average annual increase of 0.7%. The nuclear power and hydropower production increased 239 Mtoe, accounting for 19.0% of total, with average annual increase of 3.4%. According to the data above-mentioned, the increase of nature gas is the fastest, reaching annual increase of 52.2 Mtoe (that is, 246 million barrels of oil). And the coal consumption increased slowly, with annual increase of 15.7 Mtoe (24 Mtce). In addition, the production of nuclear and hydropower increased quite fast, reaching annual increase of 23.9 Mtoe (37 Mtce).

1.2 Development tendency of world energy

In the worldwide, the faster the economy development is, the higher the energy consumption per capita is. The development of economy causes the increase of energy consumption. The increase of the income level of people will inevitably lead to the promotion of the people living quality and the development of tourist and entertainment industry, and all of these require the increase of energy consumption. In 1994, the energy consumption per capita of the world was 1.433 toe, and that of the developed countries was 5.066 toe, as early as 1980 that of the developed countries was 4.644 toe.

According to the prediction of the international authoritative energy institution, up to 2050, the energy consumption per capita of the world will be 2~2.5 toe, and that of the country of OECD will be 5.6 ~6.7 toe. If the ecological factors are considered, the energy consumption per capita of the world in 2050 will be 1.4 toe, and that of country of OECD will be 3 toe. According to the analysis to the variation trend of three major energy consumptions (oil, coal and nature gas), it is believed that the oil market will be still powerful with vigorous supply and demand in the early of the 21st century. Nature gas develops very rapidly in recent years. Compared with the oil and coal, nature gas is cleaner and more convenient fuel. According to the estimation of the recoverable reserves and the prices of oil and nature gas, the demand for oil and nature gas will continue to increase before 2015, and they are still in the major position in the primary energy mix. However, the continuous decrease of the reserves of oil and nature gas will create favorable opportunity for the introduction of the substitute energy into the energy market, and the substitute energy will enter into a stage of large-scale exploitation and commercialization. Renewable energy and new energy without or low carbon content, raw coal through the special treatment and clean coal technology will all become the effective substitute resources for human beings.

2 Status and development tendency of Chinese energy industry

2.1 Status and features of Chinese energy consumption

In 1996, the total energy consumption in China is 1.61 Btce. The energy consumption per capita for urban residents is 239 kgce, while that of rural residents is only 85 kgce. The consumption of commercial energy is 1.39 Btce (coal: 75%, oil: 17.5%, nature gas: 1.6%, hytropower: 5.9%), and that of non-commercial energy is 0.22 Btce, which are biologic energies

such as firewood and straw. And the consumption of non-commercial energy makes up 13.6 percent of the total consumption. In 1996, the electricity production is 1079.4 billion kWh, and the power generation and the heat supply consume 520 Mt coal, 13.17 Mt oil and 14.5 Bm^3 nature gas.

In the 15 years of 1980-1995, the primary-energy consumption of China has increased from 600 Mt to 1290 Mt, with average annual increase of 5.2%, and the average increase in the "6th five-year plan", "7th five-year plan" and "8th five-year plan" is respectively 4.93%, 5.18% and 5.5%, showing ascendant trend of the primary energy consumption in China. And the mix of the primary energy production and consumption in past 10 years in China are shown in the attached table 5-6 and 4-7.

Attached table 5-6 Mix of Primary Energy Production of China (1980~1996)

Unit: %

Year	Raw Coal	Crude Oil	Nature Gas	Nuclear and Hydro Power
1980	69.4	23.8	3	3.8
1985	72.8	20.9	2	4.3
1990	74.2	19.0	2	4.8
1991	74.1	19.2	2	4.7
1992	74.3	18.9	2	4.8
1993	74.0	18.7	2	5.3
1994	74.6	17.6	1.9	5.9
1995	75.3	16.6	1.9	6.2
1996	74.8	17.1	1.9	6.2

Source of data: *Statistical Yearbook of China.*

Attached table 5-7 Mix of Primary Energy Consumption of China (1980~1996)

Unit: %

Year	Raw Coal	Crude Oil	Nature Gas	Nuclear and Hydro Power
1980	72.2	20.7	3.1	4.0
1985	75.8	17.1	2.2	4.9
1990	76.2	16.6	2.1	5.1
1991	76.1	17.1	2.0	4.8
1992	75.7	17.5	1.9	4.9
1993	74.7	18.2	1.9	5.2
1994	75.0	17.4	1.9	5.7
1995	75.0	17.3	1.8	5.9
1996	75.0	17.5	1.6	5.9

Source of data: *Statistical Yearbook of China.*

From 1980 to 1990, the ratio of coal in energy production mix of China increased from 69.4% to 74.3%, while the ratio of oil decreased from 23.8% to 19.0%. In the mix of energy consumption, the ratio of coal increased from 72.2% to 76.2%, while that of oil decreased from

20.7% to 16.6%. However, in the period of "the 8th five-year plan", there were changes in the mix of energy production and consumption. In the mix of energy production, the ratio of coal increased from 74.2% to 75.5%, and that of oil decreased from 19.0% to 16.7%. And in the mix of energy consumption, the ratio of coal decreased from 76.2% to 75%, while that of oil increased from 16.6% to 17.3%. Although the changes of the ratio of coal and oil are in a narrow range, they have profound meaning and indicate the future development tendency. It is marked that the traditional and relatively independent equilibrium system of energy in China is to be changed into an open-up equilibrium system of energy, and China begins to make use of the resources both at home and abroad to satisfy the needs of the development at home. In 1993, China changed from the net export country of oil to the net import country of oil. In 1996, China became the net import country of crude oil. This change also marks that the dominant position of coal in the energy supply mix has not meet the optimizing energy demands in China.

2.2 Future development tendency of Chinese energy industry

2.2.1 Prediction on energy demand

• Prediction on the demand of commercial energy

The demand of commercial energy in China in 2000, 2010, 2020 and 2030 is respectively 1.55, 2.03, 2.66 and 3.44 Btce, the consumption of commercial energy per capita is respectively 1196, 1410, 1706 and 2178 kgce. For detail to see attached table 5-8.

Attached table 5-8 Prediction on Total Commercial Energy Demand

Year	Rate of Increase of Total Value(%)	Rate of Increase of Energy (%)	Year	Elastic Coefficient of Energy Consumption	Demand of Energy (10^4t C.E)	per Capita (kg C.E)
1991～1995	12.00	5.85	1995	0.657	131176	1083
1996～2000	8.66	3.45	2000	0.310	155441	1196
2001～2005	7.52	2.64	2005	0.380	177028	1294
2006～2010	7.00	2.78	2010	0.410	203077	1410
2011～2015	6.65	2.77	2015	0.420	232784	1553
2016～2020	6.50	2.71	2020	0.415	266089	1706
2021～2025	6.37	2.66	2025	0.420	303482	1897
2026～2030	6.25	2.55	2030	0.400	344195	2178

Source of data: *Statistical Yearbook of China.*

• Prediction on the demand of biomass energy

With the development of economy and society in China, the people living level in countryside is increasing continuously, and the population of the countryside will be transferred to the urban gradually. The demand of commercial energy and high-quality energy will be increasing continuously, while the direct consumption of the biomass energy will be decreasing year by year. The demand of biomass energy in the countryside of China in 2000, 2010, 2020 and 2030 will decrease gradually to 210, 180, 150 and 130 Mtce.

Attached table 5-9 Estimation on Total Demand of Biomass Energy

Year	Ratio of Energy Save	Year	Demand of Biomass Energy (10^4 tce)
1991～1995	-	1995	21933*
1996～2000	1.0	2000	21069
2001～2005	1.5	2005	19535
2006～2010	1.5	2010	18113
2011～2015	1.5	2015	16795
2016～2020	2.0	2020	15181
2021～2025	2.0	2025	13723
2026～2030	1.5	2030	12724

* The consumption of the whole country in 1996.

• Total volume of future energy demand in China

The total volume of energy demand of China in 2000, 2010, 2020 and 2030 is respectively 1.76, 2.21, 2.81 and 3.57 Btce. The total volume and the mix of future energy demand in China are shown in the attached table 5-10.

Attached table 5-10 Total Volume and Mix of Future Energy Demand in China

		Coal (10^4 t)	Oil (10^4 t)	Nature Gas (10^8 m^3)	Hydro Power (10^8 kWh)	Nuclear Power (10^8 kWh)	Renewable Power (10^8 kWh)	Substitute Nature Gas (10^8 m^3)	Substitute Energy (10^4 t CE)	Biomass Energy (10^4 tce)	Total (10^4 tce)
1995	Output	137584	16069	178	1869	128	1.68	0.5	—	—	—
	CE	98277	22956	2361	7084	486	6	7	0	21933	153109
	Ratio (%)	64.19	14.99	1.54	4.63	0.32	0.00	0.00	0.00	14.33	100.0
2000	Output	158388	20000	265	2589	140	22.4	2	—	—	—
	CE	113137	28572	3525	9579	518	83	27	1000	20000	176440
	Ratio (%)	64.12	16.19	2.00	5.43	0.29	0.05	0.02	0.57	11.34	100.0
2005	Output	169838	23754	500	3610	436	112	10	—	—	—
	CE	121315	33935	6650	12996	1568	403	133	2000	18.000	197000
	Ratio (%)	61.58	17.23	3.38	6.60	0.80	0.20	0.07	1.02	9.14	100.0
2010	Output	180185	27805	1000	4560	1086	280	40	—	—	—
	CE	128706	39723	13300	15960	3799	980	532	3000	15000	221000
	Ratio (%)	58.24	17.97	6.02	7.22	1.72	0.44	0.24	1.36	6.79	100.0
2015	Output	192112	32234	1400	5700	1736	560	400	—	—	—
	CE	137225	46050	18620	19095	5814	1876	5320	4000	12000	250000
	Ratio (%)	54.89	18.42	7.45	7.64	2.33	0.75	2.13	1.60	4.80	100.0
2020	Output	200971	36470	1800	6840	2386	1120	1000	—	—	—
	CE	143553	52101	23940	21888	7634	3584	13300	5000	10000	281000
	Ratio (%)	51.09	18.54	8.52	7.79	2.72	1.28	4.73	1.78	3.56	100.0
2025	Output	198490	40266	2000	9120	4670	2240	2000	—	—	—
	CE	141782	57524	26600	28728	14711	7056	26600	8000	6000	317000
	Ratio (%)	44.73	18.15	8.39	9.06	4.64	2.23	8.39	2.52	1.89	100.0
2030	Output	203152	43378	2000	10260	3686	4480	4000	—	—	—
	CE	145112	61969	26600	31806	11425	13888	53200	9000	4000	357000
	Ratio (%)	40.65	17.36	7.45	8.91	3.20	3.89	14.90	2.52	1.12	100.0

2.2.2 Future development tendency of energy

Up to now, the total production of primary energy of China (including raw coal, crude oil, nature gas, hydro power and nuclear power) has kept ahead in the world, but the per capita energy production is lower than the average level of the world. Thus, in the period of the future, the energy construction of China should be centered on the power construction, the energetic exploitation of hydropower and nature gas, the moderate development of nuclear power, and the active development of the new energy and renewable energy. The rate of exploitation of hydro energy resources (by installed capacity) in 2000, 2010, 2020 and 2030 will be 18.6%, 28.0%, 42.0% and 66.0% respectively. The increase of oil consumption in 2010, 2020 and 2030 will be 3.35%, 2.75% and 1.75% respectively. The assumed consumption of nature gas in 2000, 2010, 2020 and 2030 will be respectively 26.5, 100, 80 and 200 Bm^3, and the part used for power generation will raise year by year. The installed capacity and annual electricity generation of nuclear power in 2010, 2020 and 2030 will be respectively 1.67×10^7 kW and 1.086×10^{11} kWh, 3.67×10^7 kW and 2.386×10^{11} kWh, 5.67×10^7 kW and 3.686×10^{11} kWh. Thus the department concerned has proposed: speed up the development of hydro power, and especially put emphasis on the development of the large-scale hydro power stations with adjusting capacity; encourage the power generation with nature gas and liquefied nature gas in the area with certain conditions; plan to construct a group of nuclear power stations in the area with certain conditions.

In the future energy mix, coal play still an important role. Clean coal technologies will be developed greatly, including coal conversion, coal clean up, coal preparation, coal water slurry, coal gasification and coal liquefaction. Moreover, China will develop vigorously the substitute resources of energy (that is, renewable energy), such as wind power and solar energy, which have begun to occupy a portion in the future energy mix. The renewable energy is a kind of clean energy without pollution, which has broad prospect of development. From now on, the government begins to adopt the encouraging financial policies to promote the development of renewable power. It is estimated that the ratio of the renewable power in 2000, 2010, 2020 and 2030 will be respectively 0.05%, 0.44%, 1.28 and 3.89%. In addition, the substitute of nature gas, which means coal gasification, non-conventional oil gasification, coalbed methane and so on, will be developed vigorously. The substitute energy can serve for human beings at least several centuries. The ratio of the substitute nature gas in the energy mix in 2000, 2010, 2020 and 2030 will be respectively 0.02%, 1.36%, 4.73% and 14.90%. The development of the substitute energy, which means coal liquefaction, application of other clean coal technologies, processing and conversion of biomass energy and so on, will play a key role in improving energy consumption mix for a considerable long period of time. The ratio of the substitute energy in energy mix in 2000, 2010, 2020 and 2030 will be respectively 0.57%, 1.36%, 1.78% and 2.52%.

3 Role of coal in the Chinese energy development strategy and thinking of coal technologies development

3.1 Role of coal in the future energy development strategy in China

3.1.1 Position of coal in energy consumption mix

China is the biggest country of coal consumption in the world, and the coal consumption of China in 1996 made up 29.5% of the total coal consumption of the world. In the mix of primary energy consumption, the ratio of coal is higher than 75%, which is in the overwhelming dominant position. Moreover, the ratio of coal used directly for terminal consumption is rather higher, which is 48% of the total coal consumption; however, the ratio of coal for power generation is less than 1/3, and that for coking is only 13%. The mix of energy consumption is not rational so that there is a larger gap from the advanced industrialized countries. The comparison of coal consumption between China and some

countries is shown in the attached table 5-11.

Attached table 5-11 Mix of Coal Consumption in Some Countries (1995)

Volume of Consumption (Mt)		China	USA	Russia	Japan	Poland	UK
		1376.8	853.2	160.0	126.5	102.9	78.3
Composition (%)	Power Generation	32.3	88.2	28.8	33.1	64.3	76.7
	Coking	13.4	3.5	20.6	52.2	14.1	11.1
	Industry	42.3	7.7	11.8	14.3	6.0	5.3
	Civil, Business Use and Others	12.0	0.6	38.8	0.4	15.6	6.9

Source of data: *Research on Energy Policy, Vol.2,1997.*

3.1.2 Coal demand in the future energy consumption mix of China

At present, countries with coal as the main source of the primary energy have only a small number, and most of them are the backward or the non-developed regions in economy. According to the development of energy mix, the developed countries have basically completed the conversion of the energy consumption mix from the coal as the dominant position into the oil as the dominant position, and the conversion spent a long time of 60 years. So China must pay great attention to improving the energy mix so as to reach the level of medium-developed countries in 2050. For completing the conversion of the energy consumption mix from coal to oil by 2050, China has formulated the energy development strategy. However, in fact, there are very abundant coal resources in China, and the proved reserves is 972.4 Bt, which makes up 19.2% of total coal resources. Thus the coal resources will still be in the dominant position in the future economic development. It is predicted from different schemes that in 2050, ratio of coal in the mix of primary energy consumption will still be between 45% and 55%. If the dominant position of coal in primary energy supply mix will not change, the ratio of coal will account for 65%~70% of total primary energy supply in the period of 2020~2030; and by 2050, the ratio will be still 55%~60%

of total.

In 1997, Chinese Academy of Engineering has proposed a basic programme on the China's energy development of during 2000-2050 on the basis of many factors such as the objective of economic development, the trend of population growth and the adjustment of industries structure. According to the programme, the annual increase rate of GDP of China in 1990-2000, 2000-2010, 2010-2020, 2020-2050 will be respectively 9%, 8% 5.9% 3.3%; the annual rate of energy saving will be respectively 5.87%, 4.64%, 3.01%, 2.56%. The demand of primary energy in 1990, 2000, 2010, 2020, 2050 will be respectively 1.24, 1.66, 2.27, 2.90, 3.57 Btce. The dominant positoin of coal in primary energy mix will not change greatly by 2050. For detail to see the attached table 5-12.

Attached table 5-12 Basic Programme on Energy Development of China (1990-2050)

	1990	2000		2010		2020		2050	
GDP (10^8 yuan)	17540	41520		89360		158400		415600	
Annual Increase Rate of GDP (%)	-	9.0 (1990~2000)		8.0 (2000~2010)		5.9 (2010~2020)		3.3 (2020~2050)	
Population (10^8)	11.43	13.00		14.20		14.90		15.40	
Annual Increase Rate of Population (%)	-	1.30		0.89		0.48		0.11	
Energy Consumption per Capita (tce/a)	1.085	1.278		1.599		1.946		2.318	
Energy Consumption by GDP (tce/10^4 yuan)	7.0695	3.998		2.54		1.831		0.859	
Average Rate of Power Saving (%)	-	5.87		4.64		3.01		2.56	
Demand of Primary Energy (10^4tce)	124000	166000	%	227000	%	290000	%	357000	%
Coal		107000	64.46	133700	58.90	162000	55.86	214000	59.94
Oil		24000	14.46	31000	13.66	32000	11.03	15000	4.20
Nature Gas		3900	2.35	13600	5.99	22000	7.59	17000	4.76
Hydro power		7970	4.80	17250	7.60	22600	7.79	28000	7.84
Nuclear Power		398	0.24	4000	1.76	10900	3.76	22800	6.39
New Energy		23000	13.86	27000	11.89	39900	13.76	58000	16.25
Annual Increase Rate of Energy Demand (%)	-	2.96		3.18		2.80		0.69	
Elastic Coefficient of Energy Consumption		0.329		0.398		0.475		0.209	

Even if the mix of energy supply based on premium energy, which means a pattern of oil-based energy supply, is accomplished, the direct coal consumption (including power generation) in China in 2000, 2010, 2020, 2030 will be still 1.58, 1.80, 2.01, 2.03 Bt, accounting for 64.1%, 58.2%, 51.1% 40.7% of total energy consumption respectively. And even in 2050, the ratio of coal in the mix of primary energy supply of China will be still 30%~35%.

From above, coal will be still predominant in the future energy development of China in a considerable long time of the future. Although there will gradually be some decrease in the ratio of coal in the energy mix, the importance position of coal in the national economy of China won't be substituted by other energy resources; especially in the aspects of power industry, metallurgical industry, architectural industry, chemical industry, industrial boilers and residential living, coal will still play an important role.

3.2 Thinking on the technical development of coal industry in China

Owing to the low efficiency of utilization and the serious environmental pollution, the coal-based energy mix has been a great obstacle to the economic development and social progress in China, which will influence not only the sustainable development of economy of China but also the international image of China. So there must be some adjustment on the pattern of the technical development of coal industry in China, though the primary energy of China will be still based on coal in a long time of the future.

3.2.1 Development and utilization of clean coal technology

The utilization of clean coal technology in China is not as popular as that in the developed countries. Although the high-level clean coal technology was developed much early, there evolved only a small number of fields of industrialization. In a world, the degree of the utilization of clean coal technology in China is still very low. Therefore, the development and utilization of clean coal technology should be developed vigorously, which requires to develop the coal washing, coal mixing, coal briquetting and the comprehensive utilization technology of fine coal ash, meanwhile to speed up the development and commercialization of the clean coal technology with high-technique content (such as coal gasification, coal liquefaction, high-efficiency burning and power generation technology of coal), thus accomplishing the optimization of the terminal energy consumption and the promotion of the energy utilization efficiency.

In order to accomplish the increase of the residential living standard to the level of medium-developed countries under the condition of coal-based energy supply, more and more coal is required to convert into electric power, gas fuel and liquid fuel, which can satisfy the demand of the optimization of terminal energy consumption. And for the sake of the optimization of terminal energy consumption, the ratio of coal converted into electric power in the primary-energy should be raised. By 2020-2030, the thermal power production will be 4500 billion kWh, in which the ratio of coal for power generation will increase to over 50%. In 2050, about half of coal resources will be converted into electric power, liquid fuel or coal gas, and others will be directly used fo coking, industrial boilers and kilns, civil use, commercial heating, chemical materials and so on, thus the efficiency of terminal energy utilization will increase to 55%.

The development of clean energy in China lies in the improvement of energy consumption mix and utilization of the plentiful coal resources with high efficiency. According to the programme, the coal consumption in 2020 and 2030 will be respectively 2.01 and 2.03 Bt, in which that for power generation will be 1.05 Bt and 1.51 Bt. That it, half of coal will be used for

power generation in 2020, and three quarters in 2030. In order to used coal as a clean resource of energy, the technical measures adopted are as follows: first is the direct utilization of coal (not power). For example, the residential living, municipal administration and some industries will replace the direct burning of coal with the clean coal technologies (coal briquetting, coal water slurry, coal gasification and so on). Second is the utilization of coal for power generation and the development of the technology of supercritical power generation and its corollary burners (fluid bed and entrained bed with atmospheric pressure or pressurized) and the technology of coal gasification for IGCC.

Moreover, great attention has been paid to the environmental problems caused by coal burning, especially the serious pollution of acid rain caused by the discharge of SO_2 in the courses of burning. The environmental pollution caused by energy consumption has become a serious problem, which must be considered during the course of the development of national economy of China. For controlling pollution, it was proposed in the sustainable development strategy of clean coal technology of China that the technologies of coal washing, households and industrial coal briquetting, flue gas desulfurization and coal gasification will be the favorable clean coal technologies in China before 2010. By 2010, the volume of coal washing should be 200 Mt; the volume of household and industrial briquette should be 38 Mt; the installed capacity of flue gas desulfurization should be 64 million kW; the volume of coal gasification should be 12 Mt; thus the reduction of the discharge of SO_2 will be 3.6 Mt, reduced by 29% of total SO_2 emission.

3.2.2 Technical preparations for accomplishing the strategic target of long-term optimizing energy supply

In the future, pattern of coal-based energy supply in China will not ensure that the efficiency of energy utilization in China is higher than that of the developed countries, and the requirement of environmental protection is met. Therefore, we have to follow the trend of the economic development of the world, and take the construction of the international multi-system of energy supply as the strategic target of a long-term energy mix, which requires to make the energy optimization as the main direction of development, speed up the exploitation of nature gas and convert gradually into the pattern of oil-based energy supply. In order to accomplish the target, it is required to take the exploitation of nature gas as the key point of energy development in next century, strengthen the basic facilities construction of energy (such as the pipeline network system of nature gas), and meanwhile, accelerate the R & D of clean and advanced coal conversion technologies, strengthen the international cooperation, master the lately technologies, occupy the forward position of clean utilization of coal, make technical preparations (such as coal gasification, coal liquefaction), and promote the commercialization of the technologies.

To sum up, in order to accomplish the sustainable development of energy in China, the most economical, safest, highest-efficiency and cleanest energy supply should be provided to ensure the accomplishment of the target of economic development of "reaching the level of medium-developed countries in the middle of the 21st century". In the process of future energy

development, the conversion of the pattern of energy supply into the optimizing energy mix should be accelerated, and the development and utilization of clean coal technologies should be strengthened. Thus, the project of " Feasibility of Coal Hydrogasification in China", which is carries out under the cooperation of China and Japan, can be thought as one of the technical reserves of premium energy and can satisfy the strategic target of energy development in China.

Coal gasification in China is especially emphasized as much as coal liquefaction in the clean coal programme. The technology of coal gasification itself is as the precursor of other clean coal technologies, moreover, it is very important to improve the town gas mix in China. The major purpose of the technology of coal hydrogasification is to increase the CH4-content of coal gas in the course of coal gasification as more as possible, which is prior to the technology of catalytic-synthesizing methane with CO and H_2 in the coal gas with medium heat value. So it is a cleaner fuel with higher heat value than common coal gas. In addition, the smoke and dust and SO_2 are not produced in the course of burning, which can reduce the pollution of coal smoke and acid rain, and the volume of CO_2 produced by this technology is only half or less of that by coal burning, which is advantageous to the environmental protection. Moreover, the products of coal hydrogasification can not only supply the locality, but also be transferred to the coastal areas by the original or newly-built pipelines, which can solve some problems in " northern coal transferred to south" and " western coal transferred to east". The strategy of future energy development of China has taken the " western oil transferred to east and western gas transferred to east" as the major development direction of the future transport of oil and gas in China. Several main pipelines of gas transferring will be constructed, including the west-east gas pipelines (western gas field – middle China – the Changjiang River Delta; Sichuan (四川) gas field – middle China – the Changjiang River Delta) and the south-north gas pipeline (Nanhai Sea gas field – Guangdong(广东), Guangxi(广西). By 2020, the pipeline network of nature gas will have taken shape with the connection of west-east pipelines, south-north pipelines and some other original pipelines, and the annual gas transportation is more than 150 bm^3. All of these undoubtedly laid a good foundation for the development and utilization of coal hydrogasification.